LETTER

OF THE

COMMISSIONER OF AGRICULTURE

TO THE

HON. JNO. W. JOHNSTON,

CHAIRMAN OF THE COMMITTEE ON AGRICULTURE, U. S. SENATE,

ON

SORGHUM SUGAR.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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[U.S. Dept. of agriculture. Report no. 16.]

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DEPARTMENT OF AGRICULTURE,
Washington, D. C., April 8, 1880.

Hon. JNO. W. JOHNSTON,
United States Senate:

SIR: I have the honor to acknowledge the receipt of your communication of the 24th ultimo, inclosing Senate bill No. 1514, and also the resolution introduced by Hon. A. S. Paddock, and adopted in committee, requesting the Commissioner of Agriculture "to furnish a written report giving all the information in his power in regard to the manufacture of sugar from sorghum and Chinese sugar-cane, its cost, the character and cost of the machinery necessary, &c., together with statistics of the consumption and production of sugar in the United States and all matters bearing on the subject."

Replying seriatim to these inquiries, I submit the following, in some respects hastily-prepared, statement, which, while it is not as complete an answer to the resolution as I would desire to make, yet is as full as can be prepared in the limited time at my command.

The introduction and widespread distribution by the department of the variety of sorghum called Minnesota Early Amber (the juice of which is supposed to granulate more readily than that of many other varieties) has given a great impetus within the past two years to the cultivation of the sorghum cane and to the manufacture of sugar therefrom. It is earlier than any other known variety, ripening its seed in from ninety to one hundred days, and (as appears from reports made to the department, and in which are given the results obtained in almost every State in the Union) yields bountifully an excellent quality of sirup, besides, in many cases, good sugar, although all the operations reported, except the operation of F. A. Waidner & Co. at Crystal Lake, Ill., were carried on with open-pan evaporation. It should also be remarked that these reports show that the farmers who have raised this variety of cane during the past year believe it to be better, from the quality of juice obtained, as well as from the quantity per acre, than any other variety previously cultivated. These opinions, however, are the opinions of farmers who have not had the opportunity to make comparative tests, and who compare the results with those obtained from former cultivation and manipulation, from their recollection rather than from note-books in which experiments have been carefully recorded.

We have now in the department some thirty-two varieties of sugar-producing sorghums and millets, all of which are valuable to a greater or less degree, according to the varying soil, climate, cultivation, seasons, and process of manufacture. That other valuable varieties of sorghum are to be obtained is altogether probable. The so-called Honduras sorghum is only one of the varieties native to the country of Honduras; and I have information that leads me to believe that there are several varieties growing in Central America and also at the mouth of Rio de la Plata, in South America. It is not impossible that varieties superior to any we now have may, in a few years, be common amongst us. It is of h e highest importance to the country at large that all obtainable varieties of cane should be carefully and scientifically examined; and, if possible, they should be grown in various soils and climates, that we may know which is best adapted to particular localities, which will give the best results for the least expense, and which, in the hands of the least intelligent, can be most easily manipulated.

For the northern part of the United States there is probably no cane so suitable as the Early Amber; and, perhaps, it might be said that no other variety would ripen sufficiently to yield sugar with certainty (although it might give good sirup) above the latitude of Chicago. Below this latitude the Liberian might be planted as auxiliary to the Early Amber, while in the latitude of Saint Louis and to the south of it, Honduras sorghum should be added to the other two varieties; thus extending the season for working the cane into sugar many weeks beyond the period that could be utilized in this way if but one kind of cane were planted—the Early Amber ripening in about ninety to one hundred days, the Chinese two weeks later, and the Honduras some five weeks after the Chinese, all being planted at the same time.

Illustrations of the seed-bearing tops of these different varities have been prepared for the forthcoming annual report of this department and are included in this reply, in inclosure marked A.

At a meeting of the Northwestern Cane Growers' Association held in Minnesota last season, the subject of planting, cultivating, and harvesting Early Amber cane and of its manufacture into sugar was so thoroughly discussed that a *résumé* of the proceedings of that convention will probably give as much practical information on the question as can be condensed into the same space. The convention decided that as to the kind of seed to be planted in Minnesota there was no room for debate, the Early Amber being the only sort that would ripen in that high latitude; but the discussion of the characteristics of soil best adapted to the cane showed some difference of opinion as to the availability of new land. But for fuller information touching these matters I would respectfully refer you to inclosure marked B.

The experimental work done at the department during the past two years in examining different sorghums has shown that old ideas in relation to the habit of the different varieties of this plant need to be corrected in many respects. The chemist of the department has demonstrated that there is practically but little if any difference in the juice of different varieties; that all varieties produce sugar that can be easily granulated, if the cane be taken at the proper period of growth; and that the only important question yet to be determined is as to the variety that will yield the largest amount in a given soil and climate. The Early Amber, the Liberian, the Chinese, and the Honduras, planted the past year within the corporate limits of this city, all yielded excellent results, as will be seen from the following report of the chemist of the department, prepared for our annual report for 1879 not yet published:

Hon. W. G. LE DUC,
Commissioner of Agriculture:

SIR: I have the honor to submit the following results of our recent experiments in the manufacture of sugar from the stalks of corn, sorghum, and pearl millet, made at the Agricultural Department during the year 1879.

During the past season there have been made several series of investigations for the purpose of determining the development of sugar in the juices of several varieties of sorghum and of pearl millet, and the results are such as to warrant their being given to the people at the earliest opportunity.

These investigations appear to demonstrate that there exists little difference between the various kinds of sorghum as sugar-producing plants; and, what is quite a surprising result, each of them is, at a certain period of its development, nearly if not quite as rich in sugar as the very best of sugar-cane. It is a matter, also, of extreme practical importance that this maximum content of sugar is maintained for a long period, and affords sufficient time to work up a large crop. Another result of these investigations has been to satisfactorily explain the cause of repeated failure in the production of sugar during the past quarter of a century, and to give the assurance that in the future such failure need not attend this industry. For the purpose of making clear the above points, the results obtained in the laboratory and in out-of-door experiments are appended.

The varieties of sorghum grown and subjected to continuous investigation during the season were Early Amber, White Liberian, Chinese, and Honduras, and Pearl Millet. Besides the above there were made very many examinations of other specimens of sorghums and corn-stalks; all the results of which only confirmed the general principle above stated, viz, the practical equality and great value of every variety of this plant.

In the following table are given the results of the analysis of each of the plants in the successive stages of development. It will be observed that the amount of glucose (or uncrystallizable sugar) diminishes, and the amount of sucrose (or true cane-sugar) increases. It will also be observed that the plants differ widely in the date when the sucrose is at its maximum, but are alike in this, that this maximum is attained at about the same degree of development of the plant, viz, at full maturity, as indicated by the hard, dry seed, and the appearance of off-shoots from the upper joints of the stalk. It is also to be observed that the heavy frost of October 24, which was sufficient to produce one-half inch of ice, did not cause any marked diminution of sugar.

For purpose of comparison, analyses are also appended of three varieties of sugar-cane received from Louisiana, which arrived in excellent condition, and doubtless fairly represented the average character of this famous sugar-plant.

It will be understood that the results of these tables are to be taken as a whole, since it was practically impossible to secure in each case specimen stalks for examination in the laboratory, the development of which in every case corresponded to the date when the plant was cut, and, therefore, it doubtless happened that plants taken from the same row upon September 15, for example, were in reality no further developed than those selected a week earlier, but taken as a whole the several series of analyses are convincing as showing the rate and progress of development of saccharine matter in the plant.

By reference to the tables it will be seen that the analyses made of the several sorghums under date of October 29, were, after they had been subjected to a very hard frost, sufficient to have formed ice one-half inch in thickness, and this cold weather continued for four days before this examination was made. As will be seen, there appears no diminution of sucrose in either of the stalks examined and no increase of glucose as the result of this freezing and continued exposure to a low temperature. The examination of November 8 was made after a few days of warm weather had followed this cold spell, and the influence of this subsequent thaw is noticeable in the diminution of sucrose and the increase of glucose in each specimen examined.

From this it would appear that the effect of cold, even protracted, is not injurious to the quality of the canes, but that they should be speedily worked up after freezing and before they have again thawed out. This is a matter of such practical importance that some experiments should be made to learn whether the sirup prepared from the juice of frozen cane differs from that prepared from cane not frozen but in other respects of like quality.

The Early Amber, Chinese, Liberian, and Honduras sorghums and the Pearl Millet examined, mentioned as having been grown upon the department grounds, were all planted the same day, May 15, 1879.

The relative weights of the different kinds of sorghum experimented upon are as follows:

	Pounds.
Early Amber, average of 40 stalks	1.73
White Liberian, average of 38 stalks	1.80
Chinese, average of 25 stalks	2.00
Honduras, average of 16 stalks	3.64

Since these were all grown side by side and upon land presumably of equal fertility, it will afford the data for calculating the relative amount of each variety to be grown per acre.

Early Amber.

Date.	Development.	Number of stalks used for analysis.	Height of entire stalk, in feet.	Height of top, in feet.	Height of butt, in feet.	Diameter of butt, in feet.	Weight of entire stalk, in pounds.	Weight of stripped stalk, in pounds.	Weight of top.	Weight of butt.	Per cent. of water in top.	Per cent. of water in butt.	Average per cent. of water in cane.	Weight of juice in top.	Weight of juice in butt.	Total weight of juice.	Per cent. of juice in entire cane.	Specific gravity of juice from tops.
July 18	Flower stalks just out; compact	2	6	4.3	2.4	......	3.32	2.64	......	......	82.39	83.00	82.70	.58	.57	1.15	34.6	1.046
July 26	Flower stalks begun to spread	2	8.2	5.7	2.5	......	2.74	......	......	......	75.35	51.03	63.19	.49	.59	1.08	39.6	1.064
Aug. 7	Flower stalks spreading; seed milky	2	5.1	2.8	2.3	.075	2.80	2.10	......	......	74.94	78.63	76.79	.46	.59	1.05	37.5	1.071
Aug. 11	Seed browning; harder	2	5.4	2.9	2.5	.075	2.80	2.12	......	......	71.06	76.48	73.77	.47	.59	1.06	37.9	1.078
Aug. 13	Seed harder; stalk suckering	2	5.2	2.9	2.3	.063	3.14	2.12	......	......	70.70	69.62	70.16	.45	.55	1.00	31.9	1.082
Aug. 16	......do	2	6.4	......	......	.075	3.64	2.30	......	......	89.96	72.17	80.07	.90	.69	1.59	32.7	1.081
Aug. 20	Seed nearly dry but crushable	2	5.8	3.3	2.5	.068	3.02	2.14	......	......	......	......	......	.46	.57	1.03	33.8	1.081
Aug. 22	Seed hard but splitable	2	5.6	3.1	2.5	.075	3.52	2.48	......	......	......	......	......	.50	.60	1.10	31.3	1.077
Aug. 26	......do	2	5.2	3.1	2.1	.083	4.52	2.84	......	......	......	71.97	......	.65	.76	1.41	26.9	1.081
Aug. 30	Core of cane turning red	2	5.3	......	......	.075	2.52	2.18	......	......	67.38	74.17	70.78	......	......	......	......	1.085
Sept. 8	Ripe; seed dry and mostly gone	2	5.1	2.9	2.2	.070	3.63	2.02	......	......	67.07	70.89	68.98	.388	.567	.955	26.2	1.087
Sept. 12	Ripe; seed carried away entirely	2	5.5	3.3	2.2	.06	3.56	1.79	.89	.90	68.47	76.48	72.47	.344	.379	.723	20.3	1.080
Sept. 12	Ripe and dry; carried away by birds	2	5.1	3.2	1.9	.08	3.77	2.02	1.01	1.01	71.61	71.45	71.53	.425	.493	.918	24.3	1.081
Sept. 16	Ripe and dry	2	5.5	3.4	2.1	.08	4.47	1.60	.90	.70	71.60	74.80	73.20	.487	.540	1.027	22.9	1.081
Sept. 22	......do	5	5.2	......	......	.075	8.80	3.80	......	......	......	......	76.75	......	......	1.775	20.0	......
Oct. 3	......do	2	5.5	3.4	2.1	.09	4.11	2.04	1.03	1.01	67.75	69.17	68.46	.467	.419	.886	21.5	1.076
Oct. 13	......do	2	5.9	3.8	2.1	.07	3.77	1.75	.87	.88	68.47	70.94	69.70	.434	.406	.840	22.2	1.082
Oct. 20	......do	2	5.7	3.4	2.3	.07	3.75	1.76	.82	.94	68.34	65.15	66.74	.337	.434	.771	21.2	1.085
Oct. 29	Leaves killed by frost	2	5.1	3.1	2.0	.09	3.03	1.80	.87	.93	68.31	70.45	69.38	.469	.540	1.009	33.3	1.092
Nov. 8	Quite dead	2	5.9	3.7	2.2	.06	2.54	1.76	.83	.93	69.98	71.83	70.90	.318	.494	.812	31.9	1.084
	Foreign.																	
Sept. 11	Brown husks full of milk (D. Smith)	2	6	......	......	.082	1.75	1.32	......	......	......	......	72.36	......	......	.513	29.2	......
Sept. 13	Just browning (Hutchinson)	2	6	3.7	2.3	.062	2.24	2.01	1.02	.99	78.95	84.82	81.88	.556	.538	1.094	48.8	1.039
Sept. 17	Between milk and dough (D. Smith)	2	6.2	3.8	2.4	.062	1.72	1.27	.67	.60	73.79	72.93	73.36	.295	.317	.612	35.6	1.076
Sept. 13	In dough (Hutchinson)	2	6	3.6	2.4	.062	2.10	1.50	.74	.76	75.83	68.27	72.05	.373	.377	.750	35.6	1.073

Early Amber—Continued.

Date.	Development.	Specific gravity of juice from butts.	Average specific gravity of juice.	Per cent. of solids in juice from tops.	Per cent. of solids in juice from butts.	Per cent. of glucose in juice from tops.	Per cent. of glucose in juice from butts.	Per cent. of sucrose in juice from tops.	Per cent. of sucrose in juice from butts.	Average per cent. of glucose.	Average per cent. of sucrose.	Solids (not sugar) in juice from tops.	Solids (not sugar) in juice from butts.	Average solids, not sugar.	Per cent. of sucrose in top by polarization.	Per cent. of sucrose in butt by polarization.	Average per cent. of sucrose by polarization.	Number of analysis.
July 18	Flower stalks just out; compact	1.048	1.047	10.28	10.81	4.7	2.9	4.2	4.7	3.77	4.43	1.43	3.27	2.35				1, 2, 5, 6
July 26	Flower stalks begun to spread	1.064	1.064	14.13	13.07	3.9	2.4	7.8	8.0	3.14	7.85	2.44	2.71	2.53				13, 14
Aug. 7	Flower stalks spreading; seed milky	1.070	1.070	15.85	13.57	3.4	2.6	11.1	11.2	2.97	11.15	1.42	1.77	1.56				17, 18
Aug. 11	Seed browning; harder	1.080	1.079	17.62	17.50	3.0	1.7	13.6	14.0	2.36	13.78	1.06	1.80	1.43				25, 26
Aug. 13	Seed harder; stalk puckering	1,082	1.082	17.52	16.63	1.9	1.6	14.2	14.3	1.74	14.25	1.49	.75	1.12				29, 30
Aug. 16	......do	1.080	1.080	17.62	16.80	1.6	1.5	15.1	14.3	1.54	14.67	.91	1.09	1.00				37, 38
Aug. 20	Seed nearly dry but crushable	1.081	1.081	18.13	18.13	1.9	1.3	14.2	14.0	1.60	14.13	2.05		3.25				41, 42
Aug. 22	Seed hard but splitable	1.074	1.075			1.5	1.5	15.0	14.6	1.48	14.78							49, 50
Aug. 26	......do	1.078	1.079		16.12	1.3	1.3	14.6	14.3	1.31	14.45		.52					57, 58
Aug. 30	Core of cane turning red	1.074	1.079	19.89	17.23	1.2	1.5	14.8	14.7	1.33	14.72	3.92	1.02	2.47				65, 66
Sept. 8	Ripe; seed dry and mostly gone	1.075	1.081	20.50	17.35	.6	.8	9.4	7.5	.7	8.45	10.50	9.05	9.77				92, 93
Sept. 12	Ripe; seed carried away entirely	1.070	1.075	18.47	16.79	.6	.6	14.8	14.7	.6	14.75	3.07	1.49	2.28				90, 91
Sept. 12	Ripe and dry; carried away by birds	1.079	1.080	18.91	18.36	.7	.7	14.5	14.3	.7	14.4	3.71	3.36	3.53				109, 110
Sept. 16	Ripe and dry	1.079	1.080	18.82	18.70	.5	.8	16.1	15.8	.65	15.95	2.22	2.10	2.16				136, 137
Sept. 22	......do		1.079	17.67		.73	.78	14.9	14.7	.7	14.8	2.07		2.27				175, 176
Oct. 3	......do	1.070	1.073	18.63	17.27	.9	1.3	14.7	14.1	1.1	14.4	3.03	1.87	2.45	13.8			206, 207
Oct. 13	......do	1.080	1.081		18.93	.7	.7	15.9	15.7	.7	15.8		2.49		15.1	15.1	15.1	227, 228
Oct. 20	......do	1.083	1.084	20.89	20.75	1.0	.9	16.0	15.5	.95	15.75	3.89	4.35	4.12	15.1	15.2	15.15	251, 252
Oct. 29	Leaves killed by frost	1.084	1.088	21.69	20.76	.9	1.4	17.7	16.3	1.1	17.0	3.09	3.06	3.08				262, 263
Nov. 8	Quite dead	1.073	1.078	19.87	17.57	4.1	4.5	11.9	10.0	4.3	10.9	3.87	3.07	3.47				
	Foreign.																	
Sept. 11	Brown husks full of milk (D. Smith)		1.078	19.36		3.2				3.2	12.1			4.06				83
Sept. 13	Just browning (Hutchinson)	1.031	1.035	9.20	8.40	3.7	3.4	4.6	2.4	3.5	3.5	.90	2.60	1.70				100, 101
Sept. 17	Between hull and dough (D. Smith)	1.070	1.073	18.54	17.30	2.9	3.8	12.2	12.3	3.35	12.25	3.44	1.20	2.32				111. 112
Sept. 13	In dough (Hutchinson)	1.071	1.072	18.37	17.76	2.1	3.6	12.3	8.8	2.85	10.55	3.97	5.36	4.66				98. 99

Chinese.

Date.	Development.	Number of stalks used for anal.	Length of topped stalk, in feet.	Length of top, in feet.	Length of butts.	Diameter of butt, in feet.	Weight of stalk, in pounds.	Weight of stalk stripped, in pounds.	Weight of top.	Weight of butt.	Per cent. of water in top.	Per cent. of water in butt.	Average per cent. of water in cane.	Weight of juice from tops.	Weight of juice from butts.	Total weight, juice, in pounds.	Per cent. of juice on entire cane.	Specific gravity of juice from tops.
Aug. 6	Flower stalk just out, compact	2	4.8	2.7	2.1	.063	2.72	1.82	......	......	83.03	......	......	.430	.440	.870	......	1.033
Aug. 6	Flower spreading a little	2	8.1	5.8	2.3	.083	4.10	2.82	......	......	83.55	84.42	83.99	.630	.710	1.340	32.7	1.044
Aug. 12	Seeds beginning to brown	2	5.7	3.3	2.4	.083	3.60	2.52	......	......	79.17	84.15	81.66	.540	.670	1.210	33.7	1.061
Aug. 19	Seeds browner	2	6.4	4.4	2.2	.075	3.58	2.22	......	......	74.49	83.05	78.77	.450	.570	1.020	29.0	1.067
Aug. 29	Seeds soft but not milky	2	6.6	4.4	2.2	.075	3.28	2.28	......	......	67.88	70.81	69.35	.430	.490	.920	28.2	1.074
Sept. 8	Seeds still green in parts and milky	2	5.8	3.5	2.3	.093	5.62	3.55	......	......	71.84	76.46	74.15	.769	.944	1.713	30.4	1.073
Sept. 13	Seeds dropping and hard	1	7.1	4.7	2.4	.100	2.86	1.82	.91	.91	70.01	72.54	71.27	.395	.410	.805	28.1	1.085
Sept. 20	Seeds nearly gone	2	5.7	3.6	2.1	.079	4.17	2.43	1.21	1.22	76.98	72.21	74.09	.571	.586	1.157	27.7	1.082
Sept. 27	......do	2	4.9	2.9	2.0	.082	3.27	1.89	.93	.96	70.75	75.04	72.89	.417	.417	.834	25.5	1.081
Oct. 3	Dry and ripe	2	5.8	3.86	1.9	.082	4.10	2.23	1.31	.92	76.10	66.61	71.35	.516	.490	1.006	24.5	1.086
Oct. 14	......do	2	6.0	4.0	2.0	.088	4.49	2.29	1.08	1.21	66.55	73.00	69.77	.476	.670	1.146	25.5	1.081
Oct. 21	Dry and ripe, red juice	2	6.1	4.0	2.1	.081	4.43	2.35	1.05	1.30	69.88	71.93	70.90	.428	.553	.981	22.1	1.077
Oct. 29	Dry, and leaves killed by frost	2	5.2	3.2	2.0	.075	3.65	2.26	1.03	1.23	67.87	71.15	69.51	.553	.578	1.131	31.0	1.076
Nov. 8	Quite dead	2	5.6	3.6	2.0	.088	3.21	2.30	1.05	1.25	70.09	74.36	72.22	.511	.657	1.168	36.4	1.086
	Foreign.																	
Sept. 11	Seed just forming (D. Smith)	2	7.4	4.6	2.8	.083	2.84	2.30	1.16	1.14	......	......	75.07	......	......	.814	28.7	......
Sept. 17	Seed just browning (D. Smith)	2	7.4	5.3	2.1	.062	1.68	1.31	.65	.65	71.62	72.59	72.10	.315	.309	.624	37.1	1.065
Sept. 30	Seed in the milk	3	6.1	......	......	.059	2.52	1.88	......	......	73.39	72.39	72.89	.328	.368	.696	27.6	1.079
Oct. 8	Seed in dough	2	6.4	3.6	2.8	.065	3.09	2.26	1.06	1.20	68.55	70.63	69.59	.457	.494	.951	30.8	1.082

Chinese.

Date.	Development.	Specific gravity of juice from butts.	Average specific gravity of juice.	Per cent. solids in juice from tops.	Per cent. solids in juice from butts.	Per cent. glucose tops.	Per cent. glucose butts.	Per cent. sucrose tops.	Per cent. sucrose butts.	Average per cent. glucose.	Average per cent. sucrose.	Solids not sugar, in juice, from tops.	Solids not sugar, in juice, from butts.	Average per cent. solids not sugar, in juice.	Per cent. sucrose, by polarization, tops.	Per cent. sucrose, by polarization, butts.	Average per cent. sucrose by polarization.	Number of analysis.
Aug. 6	Flower stalk just out, compact	1.041	1.037	6.87	8.83	5.9	5.2	1.0	2.7	5.55	1.85	......	.92	......	......	......	......	9–10
Aug. 6	Flower spreading a little	1.048	1.046	9.02	9.84	6.2	6.3	2.7	3.4	6.1	3.05	1.2	.14	.13	......	......	......	11–12
Aug. 12	Seeds beginning to brown	1.057	1.059	12.70	12.09	5.2	4.2	6.3	6.3	4.6	6.3	1.2	.59	.89	......	......	......	21–2
Aug. 19	Seeds browner	1.063	1.065	14.00	12.12	4.6	5.9	7.1	5.8	5.25	6.45	2.3	.42	1.36	......	......	......	33–4
Aug. 29	Seeds soft but not milky	1.072	1.073	15.73	15.14	3.6	3.2	12.9	11.4	3.4	12.15	......	.54	......	......	......	......	53–4
Sept. 8	Seeds still green in parts and milky	1.071	1.072	17.79	18.01	1.7	2.8	10.5	7.6	......	......	......	......	......	......	......	......	67–8
Sept. 13	Seeds dropping and hard	1.081	1.083	20.21	22.33	.9	2.0	15.2	12.6	1.45	13.9	4.11	5.73	4.92	......	......	......	96–7
Sept. 20	Seeds nearly gone	1.081	1.081	20.21	17.52	1.4	2.6	14.2	13.3	2.0	13.75	......	.62	......	......	......	......	132–3
Sept. 27	......do	1.081	1.081	18.43	18.20	1.2	1.7	14.6	14.4	.95	14.50	2.63	2.33	.48	......	15.2	......	147–8
Oct. 3	Dry and ripe	1.079	1.082	20.44	23.73	1.6	3.2	11.4	11.9	2.4	11.65	7.44	8.63	8.03	15.3	13.5	14.4	179–80
Oct. 14	......do	1.082	1.081	18.61	19.11	1.3	1.9	14.7	15.4	1.6	15.05	2.61	1.81	2.21	14.2	15.2	14.7	213–4
Oct. 21	Dry and ripe, red juice	1.077	1.077	18.37	19.60	1.3	1.5	13.8	15.5	1.4	14.85	3.27	2.60	2.93	......	......	......	232–3
Oct. 29	Dry, and leaves killed by frost	1.077	1.076	17.83	18.51	2.1	1.6	12.5	13.8	1.85	13.15	3.23	2.43	2.83	......	......	......	253–4
Nov. 8	Quite dead	1.082	1.084	19.61	19.39	4.8	2.8	12.3	14.3	3.8	13.3	2.51	2.29	2.40	......	......	......	264–5
	Foreign.																	
Sept. 11	Seed just forming (D. Smith)	......	1.065	15.28		......	......	......	......	6.3	6.9	......	......	2.08	......	......	......	84–5
Sept. 17	Seed just browning (D. Smith)	1.058	1.061	15.59	14.37	6.9	7.7	6.9	6.6	7.3	6.7	1.79	.17	.98	......	......	......	116–7
Sept. 30	Seed in the milk	1.075	1.077	19.04	17.89	11.0	13.2	8.1	6.0	12.1	7.0	......	......	......	4.9	3.2	4.90	165–6
Oct. 8	Seed in dough	1.078	1.080	15.16	19.05	7.8	10.1	9.3	7.5	8.5	8.8	......	1.45	......	7.2	5.2	6.2	191–2

LIBERIAN.

Date.	Development.	Number of stalks used for analysis.	Length of stalk, in feet.	Length of top, in feet.	Length of butt, in feet.	Diameter at butt, in feet.	Weight of stalk, in pounds.	Weight of stalk stripped.	Weight of top, in pounds.	Weight of butt, in pounds.	Per cent. of water in top.	Per cent. of water in butt.	Average per cent. water in cane.	Weight of juice from tops.	Weight of juice from butts.	Total weight of juice, in pounds.	Per cent. of juice in entire cane.	Specific gravity of juice from tops.
July 18	Flower-stalk just out and compact	2	6.1	3.5	2.6	......	3.28	2.62	......	....	83.79	83.31	83.55	.60	.59	1.19	36.4	1.046
26	Flower-stalk spreading; seed milky	2	8.2	5.7	2.5	.083	2.64	2.52	......	....	79.71	78.93	79.32	.49	.60	1.09	38.5	1.043
Aug. 7	Flower-stalk more spreading; seed milky.	2	5.4	2.5	2.9	......	2.76	2.52	......	....	75.75	78.36	77.06	.45	.71	1.16	....	1.061
11	Seed browning; harder	2	5.8	3.0	2.8	......	3.42	2.66	......	....	72.79	76.36	71.58	.48	.62	1.10	31.7	1.079
13	Seed harder	2	5.8	3.6	2.2	.063	3.52	2.58	......	....	70.98	75.73	73.36	.66	.70	1.36	39.2	1.081
16	Juice brown in color	2	8.0	5.7	2.3	.075	3.80	2.40	......	....	71.96	72.00	71.98	.59	.62	1.21	31.0	1.087
20	Seed as before	2	8.2	5.7	2.5	.075	3.98	2.34	......	....	69.77	73.31	71.54	.50	.65	1.15	28.9	1.085
22	Seed almost dry	2	5.5	......	......	......	4.14	2.62	......	....	....	75.91	....	.59	.62	1.21	29.2	1.083
26	......do	2	5.3	3.1	2.2	.078	4.16	2.44	......	....	69.37	....	....	.58	.61	1.22	29.5	1.085
30	Butt turned red at center	2	4.9	2.6	2.3	.075	3.76	......	......	....	70.21	72.47	71.34	....	....	....	....	1.080
Sept. 8	Ripe; seed dry	1	6.5	3.9	2.6	.072	2.10	1.26	......	....	70.30	71.42	70.86	.289	.295	.581	27.8	1.083
13	Ripe; seed carried off by birds	2	5.5	2.75	2.25	.062	4.18	2.12	1.12	1.00	70.30	85.06	77.68	.453	.437	.890	21.3	1.082
15	Ripe and dry	2	5.5	2.75	2.25	.062	4.04	2.01	1.02	.99	70.98	71.84	71.41	.494	.399	.893	22.1	1.081
20	......do	2	5.2	3.20	2.0	.088	3.66	2.19	1.13	1.06	75.00	75.56	75.28	.542	.556	1.098	21.1	1.078
27	Ripe and dry; largely suckered	2	6.07	3.71	2.36	.088	4.59	2.32	1.17	1.15	70.00	72.01	71.00	.445	.529	.974	21.2	1.074
Oct. 3	......do	2	5.08	2.95	2.13	.075	3.20	1.81	.92	.89	71.72	76.10	73.91	.423	.426	.849	26.6	1.078
13	Ripe and dry; juices bright red	2	5.08	3.05	2.03	.072	3.33	1.61	.82	.79	69.22	71.68	70.45	.388	.362	.750	22.5	1.080
21	Juices bright red	2	5.74	3.38	2.36	.072	3.36	1.84	.97	.97	65.65	80.49	73.07	.346	.406	.752	22.6	1.068
29	Leaves killed by frost	2	5.08	3.05	2.03	.069	2.49	1.57	.78	.79	67.24	72.08	69.66	.344	.375	.719	28.8	1.082
Nov. 8	Quite dead	2	4.43	2.46	1.97	.079	2.18	1.21	.58	.63	69.89	71.46	70.17	.322	.323	.616	29.6	1.084
	FOREIGN.																	
Sept. 17	Seed just brown; not in milk	1	7.20	4.54	2.66	.083	2.67	2.10	1.01	1.09	74.93	78.41	76.67	.461	.428	.889	33.2	1.055
Oct. 1	Browning, but not much milk	2	6.63	4.17	2.46	.085	2.77	2.26	1.14	1.12	72.64	71.54	72.09	.426	.461	.887	32.0	1.070
8	Brown and in milk	2	7.54	4.75	2.79	.092	4.01	3.12	1.44	1.68	74.73	75.06	74.89	.662	.792	1.454	36.2	1.074
24	Brown and hard	2	7.54	4.69	2.85	.075	3.45	2.71	1.34	1.37	61.47	71.02	66.24	.423	.527	.950	27.5	1.088

LIBERIAN—Continued.

Date.		Development.	Specific gravity of juice from butts.	Average specific gravity of juice.	Per cent. solids in juice from tops.	Per cent. solids in juice from butts.	Per cent. of glucose in juice from tops.	Per cent. of glucose in juice from butts.	Per cent. of sucrose in juice from tops.	Per cent. of sucrose in juice from butts.	Average per cent. glucose in juice.	Average per cent. sucrose in juice.	Solids not sugar in juice from tops.	Solids not sugar in juice from butts.	Solids not sugar, average.	Per cent. of sucrose by polariscope in juice of tops.	Per cent. of sucrose by polariscope in juice of butts.	Average per cent. polariscope.	Number of analysis.
July	18	Flower-stalk just out and compact	1.048	1.047	9.87	10.73	5.2	3.0	4.6	6.9	4.1	5.7	.09	.83	.46	......	......	......	3, 4
	26	Flower-stalk spreading; seed milky	1.018	1.016	8.97	10.10	4.2	2.9	4.1	5.3	3.5	4.7	.72	1.87	1.30	......	......	......	7, 8
Aug.	7	Flower-stalk more spreading; seed milky.	1.066	1.064	14.76	14.53	3.6	2.8	10.0	11.9	3.2	11.0	1.14	......	......	......	......	......	15, 16
	11	Seed browning; harder	1.077	1.078	17.66	17.14	2.8	1.9	13.4	12.4	2.4	12.9	1.49	2.78	2.14	......	......	......	19, 20
	13	Seed harder	1.081	1.081	17.45	17.65	2.2	1.7	13.4	14.2	2.0	13.8	1.78	1.75	1.77	......	......	......	27, 28
	16	Juice brown in color	1.083	1.085	18.81	18.81	1.2	1.4	13.8	14.7	1.3	14.3	3.84	2.70	3.27	......	......	......	31, 32
	20	Seed as before	1.080	1.083	18.90	17.61	1.6	1.5	15.2	13.7	1.5	14.4	2.12	2.49	2.31	......	......	......	39, 40
	22	Seed almost dry	1.081	1.082	......	......	1.4	1.4	15.3	14.0	1.4	14.7	......	......	......	......	......	......	43, 44
	26	......do	1.077	1.082	17.95	15.60	1.3	1.4	14.1	13.4	1.4	13.7	2.59	.82	1.21	......	......	......	51, 52
	30	Butt turned red at center	1.080	1.080	19.16	......	.8	1.2	12.4	12.1	1.0	12.2	4.00	......	......	......	......	......	59, 60
Sept.	8	Ripe; seed dry	1.081	1.082	20.41	19.35	.7	.8	8.7	10.3	.75	8.35	10.71	8.25	9.48	......	......	......	69, 70
	13	Ripe; seed carried off by birds	1.081	1.080	19.33	19.40	.5	.6	......	16.4	.55	......	......	2.40	......	......	......	......	94, 95
	15	Ripe and dry	1.080	1.080	18.95	18.40	.6	.7	11.3	13.9	.65	12.6	7.05	3.80	5.42	......	......	......	102, 103
	20	......do	1.073	1.075	17.12	15.97	.6	1.0	14.4	14.1	.8	14.25	2.12	.87	1.19	......	......	......	130, 131
	27	Ripe and dry; largely suckered	1.082	1.078	17.05	18.32	.7	1.2	15.8	14.6	.95	15.2	.55	2.52	1.53	14.1	15.3	14.7	145, 146
Oct.	3	......do	1.072	1.075	19.11	16.84	1.1	1.1	14.6	13.7	1.1	14.15	3.44	2.04	2.74	13.9	13.4	13.65	177, 178
	13	Ripe and dry; juices bright red	1.074	1.077	19.08	17.62	.9	1.0	14.7	13.4	.95	14.05	3.48	3.22	3.35	14.15	......	......	208, 209
	21	Juices bright red	1.068	1.068	16.37	16.31	1.1	1,1	11.1	12.5	1.1	11.8	4.17	2.81	3.49	......	......	......	230, 231
	29	Leaves killed by frost	1.079	1.081	19.48	19.49	1.5	2.7	14.3	13.5	2.1	13.9	3.68	3.29	3.48	......	......	......	255, 256
Nov.	8	Quite dead	1.070	1.077	18.86	15.75	2.9	5.2	12.8	8.4	4.0	10.6	3.16	2.15	2.65	......	......	......	266, 267
		FOREIGN.																	
Sept.	17	Seed just brown; not in milk	1.051	1.053	13.25	12.94	4.9	7.2	7.4	5.2	6.05	6.2	.95	.54	.74	......	......	......	117, 118
Oct.	1	Browning, but not much milk	1.068	1.063	16.77	16.24	8.9	9.9	8.2	7.1	8.55	8.50	......	......	......	......	......	......	167, 168
	8	Brown and in milk	1.065	1.069	13.16	17.64	4.9	8.3	11.6	......	6.65	......	......	......	......	......	......	......	189, 190
	24	Brown and hard	1.087	1.087	16.77	21.12	2.3	3.9	17.2	16.8	3.1	17.00	......	.42	......	......	......	......	241, 242

Honduras.

Date.	Development.	Number of stalks used for analysis.	Length of topped stalk, in feet.	Length of top, in feet.	Length of butt, in feet.	Diameter at butt, in feet.	Weight of whole stalk, in pounds.	Weight of stalk stripped.	Weight of top, in pounds.	Weight of butt, in pounds.	Per cent. of water in top.	Per cent of water in butt.	Average per cent. of water in stock.	Weight of juice from tops, in pounds.	Weight of juice from butts, in pounds.	Total weight of juice, in pounds.	Per cent. of juice in entire cane.	Specific gravity of juice from tops.	Specific gravity of juice from butts.
Aug. 12	No sign of flower stalk; cane 7 ft. high	2	5.8	......	......	......	6.76	5.02	......	......	....	83.99	....	1.17	1.15	2.32	34.4	1.032	1.037
19	Flower stalk just out	2	7.2	4.3	2.9	.104	7.34	5.48	......	......	83.83	84.15	83.99	1.26	1.42	2.68	36.5	1.037	1.042
29	Flower stalk spreading	2	9.1	......	......	.104	7.48	5.98	......	......	83.09	79.67	81.33	1.18	1.85	3.03	37.7	1.040	1.045
Sept. 10	Stamens just fallen; no milk	1	10.1	6.3	3.8	.093	3.21	2.57	......	......	73.51	81.53	77.52	.564	.677	1.241	38.6	1.047	1.050
10	Beginning to brown	1	9.5	6.1	3.4	.125	3.85	2.88	1.25	1.63	80.51	81.73	81.12	.670	.765	1.435	37.2	1.056	1.051
15	In first milk; browning	1	9.7	7.5	2.2	.114	4.32	3.33	1.58	1.75	75.29	80.29	77.79	.730	.811	1.541	35.6	1.057	1.054
19	In milk; brown	1	9.1	5.8	3.3	.093	2.76	1.98	1.02	.96	75.00	75.78	75.39	.426	.427	.853	30.9	1.057	1.057
25	Full milk	1	9.8	6.6	3.2	.098	3.21	2.53	1.17	1.36	77.03	80.26	78.64	.542	.670	1.212	37.4	1.059	1.057
29	....do	1	9.2	6.0	3.2	.115	4.08	2.90	1.27	1.63	76.10	77.10	76.60	.525	.717	1.242	30.4	1.060	1 061
Oct. 4	Dough	1	9.9	6.4	3.5	.121	4.06	3.00	1.35	1.65	72.52	75.52	74.02	......	.743	......	......	1.070	1.066
14	....do	1	10.8	7.2	3.6	.112	4.08	2.94	1.39	1.55	64.15	69.19	66.62	.520	.642	1.162	28.4	1.074	1.070
20	Harder	1	10.5	7.0	3.5	.112	3.75	2.79	1.29	1.50	68.27	70.52	69.39	.503	.644	1.147	30.6	1.080	1.079
29	Harder; leaves dead	1	10.3	6.7	3.6	.088	3.38	2.92	1.23	1.69	68.85	74.00	71.42	.536	.633	1.169	34.5	1.077	1.074
Nov. 8	Quite dead	1	10.2	6.7	3.5	.105	3.09	2.69	1.25	1.41	69.21	72.27	70.74	.586	.759	1.345	43.5	1.086	1.075
	FOREIGN.—D. SMITH.																		
Sept. 17	Not brown nor milky; heads well out	1	8.3	5.4	2.9	.114	1.85	1.49	.70	.79	67.22	76.55	71.88	.276	.373	.649	35.0	1.047	1.044
Oct. 1	Young; flower-tops spreading	2	10.8	8.2	2.6	.082	2.58	2.07	1.02	1.05	61.46	68.96	66.71	.284	.392	.676	26.2	1.066	1.058
8	Browning	2	9.0	6.1	2.9	.125	5.81	4.48	2.03	2.45	57.39	76.72	67.05	.860	1.036	1.896	32.6	1.075	1.062
24	Tall stalk; seed first milk	1	7.7	4.6	3.1	.115	3.08	2.61	1.30	1.31	75.77	74.35	75.06	.624	.754	1.378	44.7	1.075	1.070
24	Shorter and more stalky and riper	2	6.2	3.9	2.3	.092	2.83	1.85	.87	.98	63.04	62.35	62.69	.247	.351	.598	21.1	1.065	1.069
	ARSENAL.																		
Sept. 30	Seeds not filled out	1	8.2	5.0	3.2	.092	2.19	1.81	.85	.96	79.40	78.10	78.75	.445	.529	.974	44.4	1.050	1.052
Oct. 15	Seeds greenish brown	1	9.7	5.9	3.8	.102	2.15	1.79	.77	1.02	76.81	....	....	.373	.531	.904	42.0	1.054	1.054

Honduras—Continued.

Date.	Development.	Average specific gravity of juice.	Per cent. solids in juice from tops.	Per cent. solids in juice from butts.	Average per cent. solids in juice.	Per cent. glucose in juice of tops.	Per cent. glucose in juice of butts.	Per cent. sucrose in juice of tops.	Per cent. sucrose in juice of butts.	Average per cent. glucose in juice from cane.	Average per cent. sucrose in juice from cane.	Solids not sugar in juice from tops.	Solids not sugar in juice from butts.	Average per cent. solids not sugar in juice.	Per cent. sucrose by polariscope. tops.	Per cent. sucrose by polariscope in juice of butts.	Average per cent. sucrose by polariscope in juice.	Number of analysis.
Aug. 12	No sign of flower stalk; cane 7 feet high	1.035	6.04	6.97	6.50	4.10	6.2	1.7	.8	5.13	1.2	.24	......	......	......	......	......	....
19	Flower stalk just out	1.040	7.63	8.46	8.01	5.1	5.0	2.2	3.4	5.20	3.8	.03	......	......	......	......	......	....
29	Flower stalk spreading	1.043	8.27	9.44	8.80	4.9	5.1	4.0	4.4	5.00	4.2	....	......	......	......	......	......	....
Sept. 10	Stamens just fallen; no milk	1.058	Burned.	....	....	3.4	4.0	6.2	5.7	3.7	5.9	....	......	......	......	......	......	75–76
10	Beginning to brown	1.053	12.21	11.32	11.76	3.5	4.1	7.9	6.7	3.8	7.3	....	......	......	......	......	......	77–78
15	In first milk; browning	1.055	13.66	12.56	13.11	3.7	4.0	8.9	8.0	3.8	8.4	1.66	.56	.81	......	......	......	104–5
19	In milk; brown	1.057	13.82	14.60	14.21	2.8	3.1	8.5	8.7	2.9	8.6	2.52	2.80	2.66	......	......	......	127–8
25	Full milk	1.058	13.31	13.23	13.27	2.9	3.8	9.4	8.2	3.3	8.8	1.01	1.23	1.12	9.55	8.7	9.1	143–4
29	...do	1.060	13.92	14.20	14.06	2.4	3.3	10.6	10.4	2.8	10.5	.92	.50	.71	10.0	10.1	10.0	153–4
Oct. 4	Dough	1.068	17.09	16.61	16.85	2.2	3.5	13.0	11.6	2.8	12.3	1.89	1.51	1.70	12.2	10.7	11.4	181–2
14	...do	1.072	17.48	17.72	17.60	1.0	1.8	14.6	14.4	1.4	14.5	1.88	1.22	1.55	13.7	14.0	13.8	211–12
20	Harder	1.079	22.78	19.40	21.09	1.2	1.4	11.9	15.4	1.3	15.1	7.68	2.60	5.10	......	......	......	225–26
29	Harder; leaves dead	1.075	17.67	17.88	17.77	1.1	1.9	15.0	13.5	1.5	14.2	1.57	2.48	2.02	......	......	......	249–50
Nov. 3	Quite dead	1.080	19.51	17.35	18.44	3.9	3.1	13.4	12.7	3.5	13.0	2.24	1.55	1.89	......	......	......	268–69
	FOREIGN.—D. SMITH.																	
Sept. 17	Not brown nor milky; heads well out	1.045	10.77	10.49	10.63	5.6	5.7	3.6	3.6	5.6	3.6	1.52	1.19	1.35	......	......	......	119–20
Oct. 1	Young; flower-tops spreading	1.062	11.96	13.25	12.60	10.9	11.4	3.4	3.7	11.1	3.6	....	......	......	1.0	.7	.8	163–4
8	Browning	1.068	12.77	14.68	13.72	6.8	8.1	5.6	5.7	7.4	5.6	.37	.88	.62	4.2	4.2	4.2	187–8
24	Tall stalk; seed first milk	1.072	18.14	17.17	17.65	4.3	6.5	13.0	10.7	5.4	11.8	.84	......	......	......	......	......	237–8
24	Shorter and more stalky and riper	1.067	14.34	14.05	14.19	4.6	6.4	7.1	5.8	5.5	6.4	2.61	.85	1.74	......	......	......	239–40
	ARSENAL.																	
Sept. 30	Seeds not filled out	1.051	11.73	13.01	12.37	8.0	7.1	3.1	5.4	7.5	4.2	1.91	......	......	1.1	3.9	2.5	155–6
Oct. 15	Seeds greenish brown	1.054	....	13.74	....	7.5	8.8	4.5	4.1	8.1	4.3	....	.84	......	......	......	......	217–8

Miscellaneous sorghums.

Date.	Variety.	Development.	Number of stalks.	Length of topped stalk, in feet.	Length of top, in feet.	Length of butt, in feet.	Diameter at butt, in feet.	Weight of stalk, in pounds.	Weight of stalk stripped, in pounds.	Weight of top, in pounds.	Weight of butt, in pounds.	Per cent. of water in top.	Per cent. of water in butt.	Average per cent. of water in cane.	Weight of juice from tops.	Weight of juice from butts.	Total weight of juice.	Per cent. of juice in entire cane.	Specific gravity of juice tops.
Sept. 9	Gunnison	Green suckers	2	5.7	3.3	2.4	.073	3.71	1.91	......	......	69.42	75.69	72.55	.461	.472	.933	24.9	1.079
Sept. 9	....do	Dry suckers	2	5.4	3.1	2.3	.073	4.21	2.21	......	......	71.39	73.63	72.51	.545	.515	1.060	25.1	1.078
Sept. 16	....do	Green suckers	2	5.5	3.3	2.2	.083	4.21	2.13	1.03	1.10	81.25	72.48	76.86	.483	.553	1.036	24.4	1.079
Sept. 20	....do	Very ripe and dry	2	5.7	3.6	2.1	.079	4.13	2.02	1.03	.99	71.33	70.80	71.06	.512	.459	.971	23.5	1.082
Sept. 27	....do	......do	2	4.5	2.5	2.0	.075	4.00	1.77	1.87	.90	71.67	70.15	70.91	.401	.467	.862	21.5	1.077
Oct. 10	Mastodon		1	14.76	10.82	3.91	0.180	......	6.46	3.23	3.23	77.73	78.67	78.20	1.665	1.720	3.385	......	1.071
Oct. 10	Imphee		1	8.8	......	......	.112	2.12	1.98	......	......	......	......	75.24	......	......	1.074	50.6	......
Oct. 10	Black Top		1	10.5	......	......	.092	1.53	1.42	......	......	......	......	71.34	......	......	.746	48.7	......
Oct. 10	Oomseeana		1	7.3	......	......	.079	1.37	1.19	......	......	......	......	74.84	......	......	.606	14.2	......

Date.	Variety.	Development.	Specific gravity of juice from butts.	Average specific gravity of juice.	Per cent. solids in juice from tops.	Per cent. solids in juice from butts.	Tops, juice from, per cent. of glucose.	Butts, juice from, per cent. of glucose.	Tops, juice from, per cent. of sucrose.	Butts, juice from, per cent. sucrose.	Average per cent. of glucose in juice of cane.	Average per cent. of sucrose.	Solids, not sugar, in juice from tops.	Solids, not sugar, in juice of butts.	Average of solids, not sugar, in juice.	Sucrose in juice from tops by polarization.	Sucrose in juice from butts by polarization.	Average sucrose in juice by polarization.	Number of analysis.
Sept. 9	Gunnison	Green suckers	1.077	1.073	13.97	15.55	.7	.5	9.3	9.9	.6	9.6	5.55	4.36	4.95	......	......	......	71, 72
Sept. 9	..do	Dry suckers	1.076	1.077	17.21	......	.9	1.0	11.6	13.2	.9	12.4	4.81	......	......	......	......	......	73, 74
Sept. 16	...do	Green suckers	1.082	1.080	18.38	18.67	.6	.6	12.6	13.9	.6	13.2	5.18	4.17	4.62	......	......	......	107, 108
Sept. 20	....do	Very ripe and dry	1.080	1.081	18.77	18.11	.7	.7	15.6	15.1	.7	15.3	2.37	2.64	2.50	......	......	......	134, 135
Sept. 27	....do	......do	1.078	1.077	18.24	18.72	.7	.6	15.2	15.9	.6	15.5	2.34	2.08	2.21	......	......	......	149, 150
Oct. 10	Mastodon		1.064	1.067	16.92	15.41	1.3	5.8	14.7	8.8	3.5	11.7	.92	.81	.86	......	......	......	......
Oct. 10	Imphee		......	1.068	......	......	......	......	......	......	9.1	6.9	......	......	.28	10.5	6.1	8.3	198, 199
Oct. 10	Black Top		......	1.084	......	......	......	......	......	......	4.5	13.6	......	......	1.74	......	......	4.7	200
Oct. 10	Oomseeana		......	1.077	......	......	......	......	......	......	2.3	14.4	......	......	1.70	......	......	11.9	201

Pearl Millet.

Date.	Development.	Number of stocks for analysis.	Length of topped stalks, in feet.	Diameter at butts, in feet.	Weight of whole stalk, in pounds.	Weight of stripped stalk, in pounds.	Per cent. of water in cane.	Weight of juice, in pounds.	Per cent. of juice in stalks.	Specific gravity of juice.	Per cent. of solids in juice.	Per cent. of glucose in juice.	Per cent. of sucrose in juice.	Per cent. of solids, not sugar, in juice.	Polarization.	Number of analysis.
Sept. 10	Stamens still on	2	5.7	.062	1.67	1.12	Burned	.505	30.0	1.035	Burned	1.6	3.7	......	......	79, 80
Sept. 10	Stamens fallen	2	6.7	.062	1.57	1.04	..do ...	.480	30.5	1.034	..do ..	1.6	1.9	......	......	81, 82
Sept. 16	No change in appearance	2	5.3	.073	2.00	1.02	76.31	.373	18.6	1.049	11.17	.8	7.3	3.07	......	106
Sept. 19	......do	2	5.1	.062	1.78	1.09	76.98	.406	22.8	1.049	11.53	1.5	7.0	3.03	......	129
Sept. 25	Dry tops; suckering	3	5.7	.065	2.50	1.49	72.00	.547	21.5	1.054	11.09	1.1	8.7	1.29	......	142
Sept. 29	......do	3	6.6	.065	3.00	2.08	75.53	.783	26.1	1.060	11.21	1.2	9.6	.41	......	152
Oct. 4	Dry tops; suckers well developed	2	5.1	.056	2.09	.98	67.35	.529	25.3	1.061	14.10	1.3	10.1	2.70	......	183
Oct. 14	Leaves dead and yellow	2	6.1	.072	1.85	.97	64.41	.377	20.3	1.068	15.30	2.0	11.3	2.00	......	215
Oct. 20	Frost-withered	2	6.1	.072	1.65	1.06	65.65	.560	33.9	1.058	13.15	3.0	6.7	3.45	......	229
Oct. 29	Quite dead	3	5.6	.059	1.53	.88	72.54	.337	22.0	1.070	16.18	5.4	7.4	3.38	......	248
	Foreign.															
Oct. 24	Withered	2	5.3	.059	1.20	.77	75.77	.302	25.1	1.058	18.14	.5	11.7	5.94	......	243

Miscellaneous.

Date.	Variety.	Development.	Number of stalks.	Length of topped stalk, in feet.	Length of top.	Length of butt.	Diameter at butt.	Weight of stalk, in pounds.	Weight of stalk stripped.	Weight of top.	Weight of butt.	Per cent. of water in top.	Per cent. of water in butt.	Average per cent. of water in cane.	Weight of juice from tops.	Weight of juice from butts.	Total weight of juice.	Per cent. of juice in entire cane.	Specific gravity of juice, tops.
Sept. 17	Egyptian corn	....	3	4.9	3.0	1.9	.083	2.70	1.85	.90	.95	84.09	85.03	84.51	.329	.493	.822	30.1	1.040
Sept. 11	....do	....	2	4.4	2.9	1.5	.083	......	1.41	.58	.86	76.14	76.06	76.25	.267	.375	.642	......	1.062
Sept. 17	Fodder	....	2	6.5	4.4	2.1	.083	2.42	1.71	.77	.94	78.06	79.27	78.66	.332	.505	.837	34.6	1.035
Sept. 11	Brown doura	....	2	3.2	......	......	.041	.82	.30	......	......	....	....	70.83	......	......	.081	9.8	......
Oct. 1	... do	....	3	3.7	......	......	.049	1.58	.59	......	......	....	....	66.54	......	......	.095	6.0	......
Sept. 11	White doura	....	2	5.2	......	......	.062	1.45	.92	......	......	....	....	51.56	......	......	.207	14.2	......
Oct. 1	....do	....	3	4.3	......	......	.049	1.58	.59	......	......	....	....	....	......	......	.097	6.1	......
Aug. 23	Corn	Two weeks before plucking ears	3	5.7	3.5	2.2	.068	5.88	3.87	......	......	77.34	77.05	77.20	.460	.520	.980	24.8	1.046
Aug. 23	....do	At time of plucking ears	3	4.4	2.8	1.6	.088	6.36	3.63	......	......	73.04	....	....	.430	.670	1.100	26.0	1.051

Date.	Variety.	Development.	Specific gravity of juice, butts.	Average specific gravity.	Per cent. solids in juice from tops.	Per cent. solids in juice from butts.	Tops, glucose.	Butts, glucose.	Tops, sucrose.	Butts, sucrose.	Average glucose in juice from cane.	Average sucrose in juice from cane.	Solids not sugar in juice from tops.	Solids not sugar in butts.	Average solids not sugar, in juice.	Tops by polarization.	Butts by polarization.	Average of polarization.	No. of analysis.
Sept. 17	Egyptian corn	....	1.035	1.037	9.87	9.22	3.7	4.6	5.5	3.6	4.1	4.5	.67	1.02	.84	......	......	......	......
Sept. 11	... do	....	1.064	1.063	14.68	15.07	2.9	2.6	7.6	7.9	2.7	7.7	4.18	4.57	.37	......	......	......	......
Sept. 17	Fodder	....	1.025	1.030	7.93	5.27	4.4	1.8	1.4	1.5	3.1	1.4	2.13	1.97	2.05	......	......	......	......
Sept. 11	Brown doura	....	....	1.055	....	....	......	......	......	......	.8	3.7	......	......	12.51	......	......	......	88
Oct. 1	.. do	....	....	1.056	....	....	......	......	......	......	2.7	3.7	......	......	4.88	......	......	......	160
Sept. 11	White doura	....	....	1.084	....	....	......	......	......	......	1.9	8.7	......	......	7.00	......	......	......	......
Oct. 1	.. do	....	....	1.086	....	....	......	......	......	......	......	......	......	......	......	......	......	......	......
Aug. 23	Corn	Two weeks before plucking ears	1.049	1.048	....	....	4.8	4.9	4.9	6.4	4.8	5.6	......	......	......	......	......	......	......
Aug. 23	....do	At time of plucking	1.017	1.049	....	....	3.4	3.4	7.1	6.3	3.4	6.7	......	......	......	......	......	......	......

Louisiana sugar canes.

Date.	Variety.	Portion.	Number of stalks.	Total weight, in pounds.	Weight of leaf top.	Weight of bare cane.	Weight of top, stripped.	Total length to end of leaves, in pounds.	Length of bare cane.	Length of leaf top, stripped.	Diameter at butt, in feet.	Diameter at first leaf.	Number of joints in butt.	Number of joints in middle.	Length of first joint.	Length of second joint.	Length of middle joint.	Length of first leaf-joint.	Per cent. of water in cane.	Weight of juice, in pounds.	Per cent. of juice.	Specific gravity of juice.	Per cent. of solids in juice.	Glucose, per cent. of, in juice.	Sucrose, per cent. of, in juice.	Per cent. of solids not sugar, in juice.	Polarization, per cent. sucrose.
Nov. 11	Ribbon-cane plant, 1879	Top	....	......	....	......	....	......	....	....	.....	.....	....	....	......	....	....	....	85.51	.668	....	1.036	7.36	4.08	1.57	.71	7.08
Nov. 11	....do	Middle.	....	......	....	......	....	......	....	....	.....	.....	....	....	......	....	....	....	79.19	2.919	....	1.056	13.62	1.98	11.30	.34	11.13
Nov. 11	....do	Butt	2	13.23	2.68	10.55	1.07	13.12	6.72	1.34	.124	.118	8	10	.291	....	....	.262	80.11	3.025	....	1.063	15.28	.71	......	.....	13.97
Nov. 11	....do	Top	....	......	....	......	....	......	....	....	.....	.....	....	....	......	....	....	....	84.90	.366	....	1.040	8.82	4.29	2.83	1.70	.....
Nov. 11	....do	Middle	....	......	....	......	....	......	....	....	.....	.....	....	....	......	....	....	....	78.18	1.464	....	1.057	13.79	1.61	11.30	.88	.....
Nov. 11	....do	Butt	1	6.00	1.19	4.81	.68	12.89	6.99	1.57	.124	.115	9	11	.239	....	.426	.220	76.19	1.486	....	......	......	.81	13.64	.....	.....
Nov. 11	....do	Top	....	......	....	......	....	......	....	....	.....	.....	....	....	......	....	....	....	81.81	.761	....	1.031	10.96	2.94	6.30	1.72	5.97
Nov. 11	Ribbon-cane plant, 1878	Middle.	....	......	....	......	....	......	....	....	.....	.....	....	....	......	....	....	....	91.90	2.381	....	1.067	16.31	.68	15.82	.....	15.79
Nov. 11	....do	Butt	2	10.26	2.63	7.63	1.35	11.81	5.81	1.57	{ .127 / .121 }	.112	6	9	{ .164 / .295 }	.246 / .361	....	.262 / .164	71.63	2.055	....	1.074	17.71	.45	17.17	.09	17.00
Nov. 11	Red cane, 1878	Top	....	......	....	......	....	......	....	....	.....	.....	....	....	......	....	....	....	81.97	.739	....	1.047	10.32	3.41	2.14	4.77	5.06
Nov. 11	....do	Middle.	....	......	....	......	....	......	....	....	.....	.....	....	....	......	....	....	....	75.67	2.795	....	1.064	15.59	1.41	13.36	.82	14.07
Nov. 11	....do	Butt	2	11.65	2.30	9.35	1.30	11.48	6.47	1.71	{ .131 / .115 }	.108	....	....	.203	....	....	.118	78.22	3.113	....	1.066	15.69	1.04	15.26	.39	14.59

For purpose of further comparison the following analyses of sugar-canes and juice of the sugar-cane grown in Madras, India, are given below. The canes were divided into upper, middle, and lower thirds, each third being 2 feet in length, except the lower thirds of the selected canes, which were 3 feet in length.

	Bundle of medium good canes.			Bundle of selected canes.		
	Upper third.	Middle third.	Lower third.	Upper third.	Middle third.	Lower third.
Bagasse	7.630	8.470	8.300	7.580	8.650	8.290
Sucrose	10.630	13.310	13.370	9.490	13.640	13.850
Glucose	2.640	1.510	1.540	2.430	.736	.710
Ash	.307	.259	.233	.545	.363	.349
Water	78.334	75.612	76.122	79.484	75.628	75.945
Undetermined	.459	.839	.455	.471	.983	.856
	100.000	100.000	100.000	100.000	100.000	100.000

ANALYSIS OF EXPRESSED JUICE.

Sucrose	11.510	14.550	14.580	10.270	14.930	15.110
Glucose	2.860	1.650	1.680	2.630	.806	.775
Ash	.333	.283	.255	.590	.398	.381
Undetermined	.497	.917	.485	.510	1.076	.934
Water	84.800	82.600	83.000	86.000	82.790	82.800
	100.000	100.000	100.000	100.000	100.000	100.000

CHEM. CENT. BLATT., *February*, 1880.

For more clearly presenting the facts developed by the examinations of the four kinds of sorghum, the following chart represents graphically the foregoing results:

It will be observed how closely the Early Amber and Liberian correspond in their development, being almost identical, and yet being clearly distinct varieties. It will also be seen that while these two varieties attain a content of sugar in their juices equal to the average content in the juice of sugar-cane by the middle of August, the Chinese does not reach this condition until the last of September, while the Honduras does not reach this point until the middle of October.

It will be seen also that after having attained approximately the maximum content of sugar, this condition is maintained for a long period, affording ample time to work up the crop.

It is doubless true that had the season been longer it would have been found that the Chinese and Honduras having once attained this full development of sugar would also have retained it; but, as is seen by the chart, the heavy frosts and subsequent warm weather which happened about November 24, caused a rapid diminution of sucrose in each variety, and a corresponding increase in glucose.

The converse of what is found true of the sucrose is clearly shown as to the development of the glucose, and it is seen that a minimum quantity once attained is continued a long time, and that this minimum is quite as low as the average amount found present in the sugar-canes.

It is obvious that the results depicted upon the chart are not to be taken as entirely exact, but the general fact represented is without doubt true, and with a still larger number of observations the approach to true curves would be found nearer than here represented.

The line representing the average per cent. of sucrose in sugar-beets is from the results of analysis of thirteen specimens of sugar-beets grown upon the Agricultural College farm, Amherst, Mass., and analyzed by Professor Groessmann (*vide* Mass. Agric. Rept., 1870–'71).

An average of all the examinations made of these four sorghums during these periods when they were suitable for cutting gives the following results:

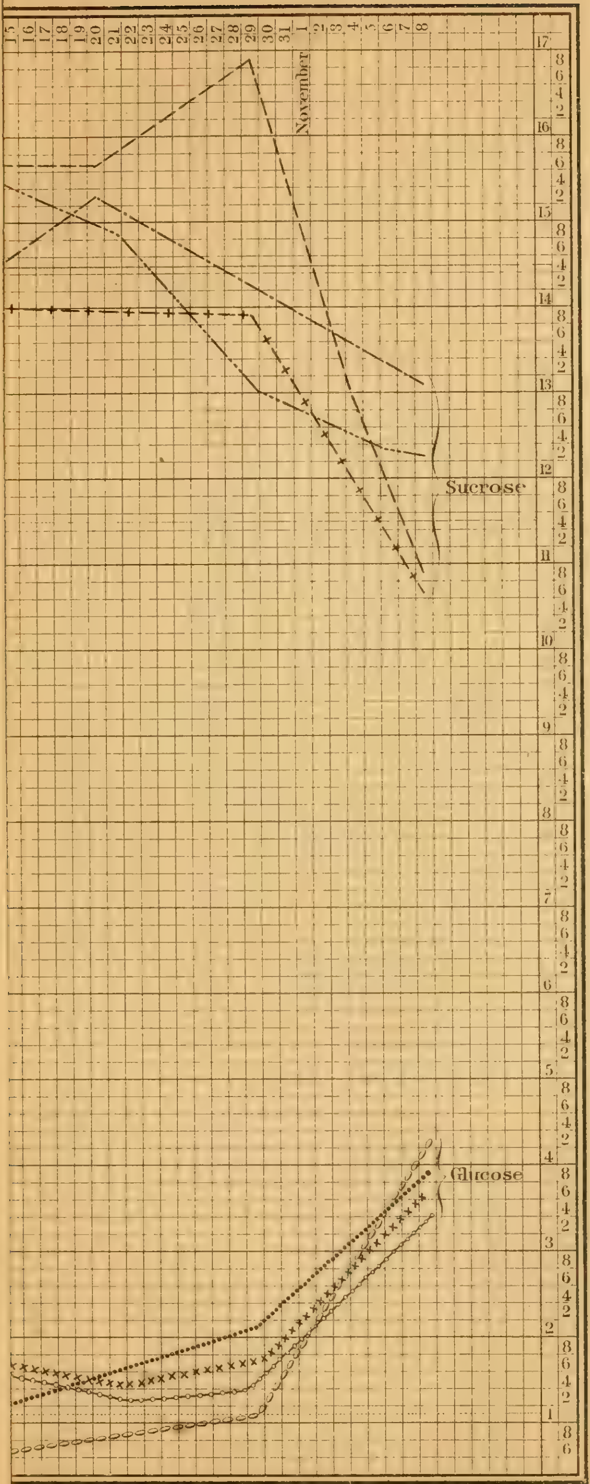
Early Amber, from August 13 to October 29 inclusive, 15 analyses extending over 78 days, 14.6 per cent. sucrose.

Liberian, from August 13 to October 29 inclusive, 13 analyses, extending over 78 days, 13.8 per cent. sucrose.

Chinese, from September 13 to October 29 inclusive, 7 analyses, extending over 46 days, 13.8 per cent. sucrose.

Honduras, from October 14 to October 29 inclusive, 3 analyses, extending over 16 days, 14.6 per cent. sucrose.

Besides the investigations above mentioned, there have been made 35 experiments



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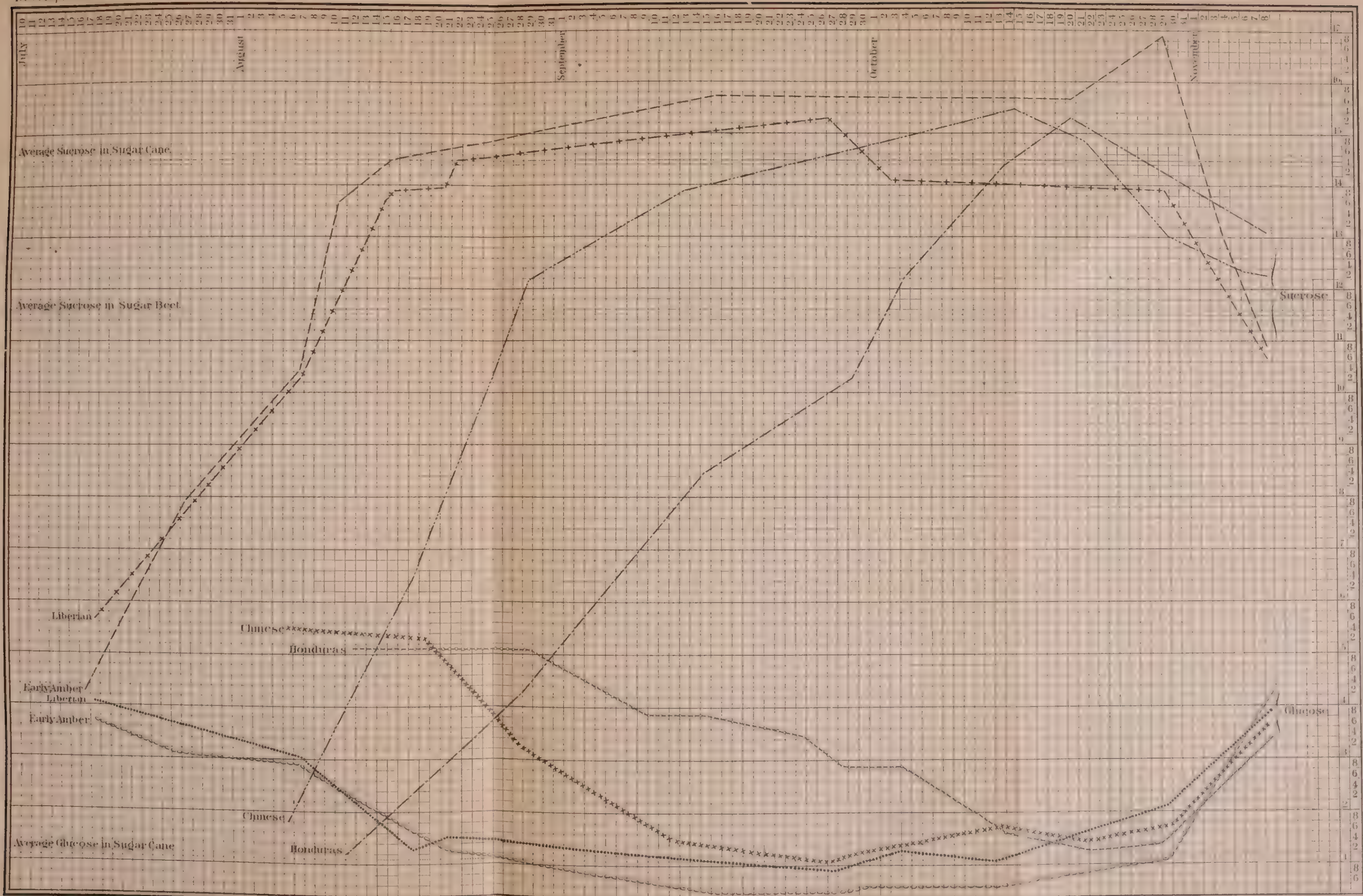
Development of Sucrose and Glucose in Sorghums



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in making sugar from cornstalks, sorghums, pearl millet, &c., in all of which there have been used over 23 tons of stalks. The result of these experiments has been to fully confirm all the experiments of the previous year, not only, but also to help towards the solution of certain questions of the highest practical importance. In every case it has been found that the quality of the sirup obtained has been precisely such as the previous analysis in the laboratory of the juice used made probable. An average of the nine best sirups obtained showed a percentage of cane-sugar present equal to 92.7 of the amount originally present in the juice, while an average of the nine poorest (*i. e.*, containing the lowest percentage of cane-sugar) showed a percentage of cane-sugar present equal to 90.1 of the amount present in the juice.

This must not be understood to mean that there has been no loss of sugar in the process of manufacture, as such conclusion would be quite erroneous, as will be seen by consulting tables further on in this report.

Below are given the detailed results of 33 experiments in the making of sirups from sorghum, pearl millet, and cornstalks, and analyses of the juices from which these sirups were made. These stalks were obtained from neighboring farmers, and, as will be seen, were never in the condition best suited for working, but the results obtained from them are, however, of great practical value, and are given in detail.

The last column represents the relative loss of sucrose in making sirup, as compared with the glucose present, but gives no indication as to the absolute loss which may have been incurred, and since the economical production of sugar largely depends upon the amount of this loss, this matter is discussed more fully in another place.

	Date of experiment.	Pounds of raw stalks.	Leaves and tops.	Tops.	Stripped stalks.	Topped stalks.	Juice expressed.	Specific gravity of juice.	Per cent. of juice in raw stalks.	Per cent. of juice to stripped stalk.	Per cent. of sucrose in juice.	Per cent. of glucose in juice.	Pounds of sirup obtained.	Per cent. of sirup in raw stalks.	Per cent. of sirup in juice.	Polarization of sirup.	Sucrose in sirup by analysis.	Glucose in sirup by analysis.	Per cent. of total solids in juice.	Per cent. of glucose in juice.	Per cent. of sucrose in juice.	Polarization of juice.	Relative loss of sucrose in making sirup.
Early amber sorghum, topped but not stripped.	Sept. 18	1,603	......	234	......	1,369	684	1057	42.67	......	8.70	4.30	98.5	6.15	14.40	46.4	......	......	13.01	4.30	8.70	......	......
	Sept. 24	2,566	......	395	......	2,171	1,063	1060	41.43	......	11.10	3.10	154.0	6.00	14.49	48.0	51.1	29.6	......	3.10	11.10	11.43	14.9
	Sept. 30	2,436	......	329	......	2,107	975	1057	40.02	......	11.10	3.50	169.1	6.94	17.16	44.3	42.3	20.6	15.41	3.50	11.10	10.50	8.7
	Oct. 1	1,778	......	258	......	1,520	660	1061	37.12	......	11.60	3.70	102.8	5.78	15.67	51.2	56.6	25.2	15.35	3.70	11.60	10.50	6.6
	Oct. 21	891	......	131	......	760	382½	1068	42.93	......	11.91	2.63	58.0	6.51	15.17	58.3	62.9	18.7	......	2.63	11.91	......	4.8
Honduras sorghum, topped and stripped.	Oct. 9	556	88	....	468	......	229	1072	41.01	48.93	12.30	2.50	41.2	7.41	18.00	51.8	60.9	16.8	16.57	2.50	12.30	11.80	4.7
Honduras sorghum, topped but not stripped.	Oct. 25	281	......	10	......	271	113	1077	40.21	......	10.49	1.14	15.5	5.52	14.40	61.0	70.2	8.6	17.38	1.14	10.49	......	1.1
Honduras sorghum, topp'd and stripped.	Nov. 1	1,405	231	....	1,174	......	666	1058	47.40	56.73	9.24	3.63	97.5	6.94	14.65	37.2	36.4	31.7	13.62	3.63	9.24	......	18.4
	Nov. 3	1,231	117	....	1,114	......	611	1058	49.63	54.85	7.70	5.10	88.5	7.19	14.47	38.1	46.3	32.9	13.49	5.10	7.70	......	1.7
	Nov. 4	1,431	155	....	1,276	......	660	1054	46.12	51.72	5.40	5.40	86.8	6.07	13.16	30.4	39.3	36.1	12.18	5.40	5.40	......	......
	Nov. 6	3,368	385	....	2,983	......	1,608	1055	47.74	53.91	6.60	5.00	221.5	6.58	13.77	33.4	33.4	33.1	......	5.00	6.60	......	6.7
Chinese sorghum, topped and stripped.	Sept. 23	319	76	....	243	......	111	1066	34.80	45.68	11.30	2.80	17.3	5.43	15.60	57.4	57.9	16.4	......	2.80	11.30	......	2.2
Chinese sorghum, topped but not stripped.	Oct. 2	296	......	49	......	247	139	1060	46.96	......	11.60	2.30	20.0	6.76	14.39	46.3	54.4	18.3	16.46	2.30	11.60	8.90	8.7
	Oct. 11	1,679	......	187	......	1,492	542	1060	32.28	......	5.58	8.06	74.9	4.46	13.82	26.3	27.8	57.5	15.18	8.06	5.58	4.80	8.3
	Oct. 25	1,709	......	245	......	1,464	562	1058	32.88	......	5.01	4.89	77.7	4.55	13.82	36.0	35.8	39.1	......	4.89	5.01	......	2.8
Liberian sorghum, topped and stripped.	Aug. 28	......	......	....	......	......	20	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	Nov. 7	2,544	454	....	2,090	......	1,009	1072	36.66	48.28	10.54	4.62	186.4	7.33	18.47	48.0	47.5	24.2	......	4.62	10.54	......	3.3
Pearl millet, topped and not stripped.	Oct. 2	378	......	31	......	347	106	1047	28.04	......	6.60	1.60	10.2	2.71	9.66	39.3	47.2	17.2	15.16	1.60	6.60	4.60	7.2
	Oct. 10	437	......	44	......	393	131	1047	30.00	......	6.36	1.49	12.4	2.84	9.48	41.4	46.8	12.7	10.03	1.49	6.36	3.50	2.3
Field corn, topped and stripped.	Sept. 29	222	67	....	155	......	70	1070	31.53	45.16	10.90	2.40	9.5	4.28	13.56	52.7	62.0	12.6	15.01	2.40	10.90	10.05	......
	Oct. 4	1,969	667	....	1,302	......	494	1035	25.09	37.94	5.40	2.30	46.0	2.34	9.31	36.9	48.1	23.9	9.43	2.30	5.40	4.06	3.3
	Oct. 7	1,519	493	....	1,026	......	384	1043	25.28	37.43	4.80	3.70	39.6	2.61	10.31	27.3	39.8	31.3	......	3.70	4.80	......	.5
	Oct. 8	1,498	472	....	1,026	......	395	1040	26.37	38.50	5.10	3.80	40.5	2.71	10.26	21.4	34.5	36.4	18.79	3.80	5.10	......	8.6
	Oct. 13	......	......	....	1,095	......	332	1038	......	30.32	2.70	4.48	36.1	......	10.87	18.5	25.5	42.0	8.07	4.48	2.70	......	.0
Egyptian sugar-corn, topped and stripped.	Sept. 11	621	240	....	381	......	159	1063	25.60	41.73	8.25	2.85	30.3	4.89	19.08	52.9	......	......	......	2.85	8.25	......	......
Stowell's Evergreen corn, topped and stripped.	Oct. 16	3,435	1,035	....	2,400	......	1,123	1042	32.69	46.79	8.28	1.19	132.0	3.84	11.75	37.8	20.9	26.1	11.91	1.19	8.28	......	42.9
	Oct. 17	4,185	1,261	....	2,924	......	1,395	1042	33.33	47.71	7.35	1.25	157.3	3.76	11.27	11.5	18.8	41.6	11.24	1.25	7.35	5.10	54.4
	Oct. 18	1,968	593	....	1,375	......	612	1044	31.10	44.51	......	......	68.8	3.50	11.25	44.3	46.7	17.2	......	......	......	......	......
Miller's sweet corn, topp'd and stripped.	Sept. 17	760	281	....	479	......	214	1042	28.16	44.68	5.20	3.80	24.2	3.21	11.39	38.1	45.3	31.2	......	3.80	5.20	......	.0
	Sept. 18	1,407	527	....	880	......	445	1051	31.63	50.57	7.40	4.20	57.6	4.09	12.94	38.1	45.3	31.2	16.24	4.20	7.40	......	4.6
	Sept. 19	1,191	441	....	750	......	254	1051	21.33	33.87	7.90	4.50	48.8	4.10	19.23	38.1	45.3	31.2	......	4.50	7.90	......	4.5
Miller's sweet corn, topp'd and not stripped.	Sept. 20	821	......	111	......	710	268	1048	32.64	......	......	......	31.9	3.88	11.88	38.1	45.3	31.2	......	......	......	......	......
	Sept. 25	1,001	......	154	......	847	294	1047	29.40	......	6.50	3.70	33.0	3.31	11.24	38.7	44.9	30.9	9.39	3.70	6.50	......	4.5

The apparatus used in the experiments, besides a few barrels and pails for holding the juice, consisted of a copper tank of the following dimensions: 4 feet 3 inches long, 2 feet 3 inches deep, 2 feet 3 inches wide; a galvanized iron pan 9 feet long 8 inches deep, 3 feet 6 inches wide. This iron pan was surrounded by a wooden frame of 2-inch plank so as to support the sides, and each pan was placed in brickwork with chimney, and so arranged as to permit a fire to be kept below it in direct contact with the bottom. In the case of the copper tank the flame played about the sides also, so as to heat the contents more rapidly. The galvanized iron pan was such as could readily be constructed by any ordinary tinsmith or mechanic. The copper tank was used for defecation with lime; the galvanized iron pan for evaporation. The process, in brief, is as follows: after topping and stripping the corn or sorghum, it was passed through the mill, and when sufficient juice had been obtained it was heated in the copper tank to a temperature of 82° C.=180° F. After the juice had reached this temperature, there was added to it, with stirring, cream of lime, until a piece of litmus paper dipped in the juice showed a purple or bluish-purple color. The heat was now raised to the boiling point, and, so soon as the juice was in good ebullition, the fire was drawn and a thick scum removed from the surface of the juice. After a few minutes the sediment from the juice subsided, and by means of a siphon the clear liquid was decanted off, leaving a muddy sediment, which was equal to about one-tenth to one-twentieth of the bulk of the juice. It was found that by means of the stop-cock at the bottom of the defecator, it was possible to draw off the clarified juice more thoroughly than by means of the siphon, so that this method has been adopted for removing the juice. It is only necessary to collect in a separate vessel the first portions of juice coming from stop-cock, which are turbid, and passing this through the bag filter with the sediment. This muddy sediment was then drawn off by means of a stop-cock and filtered through a plaited-bag filter, and the clear filtrate therefrom was added to the liquid previously siphoned off. The clarified juice, which, during the above operation, is not allowed to cool below a temperature of 66° C. or 150° F., was now emptied into the evaporating pan, and there was added to it, with stirring, a solution of sulphurous acid in water until the lime present was neutralized, as was shown by the reddening of litmus paper when it was dipped in the juice. The evaporation was now hastened as much as possible, and the juice concentrated to a sirup at a boiling point of 112° C., equal to 234° F., or thereabout. During the close of the evaporation there is great danger of scorching the sirup, and this was obviated by allowing only coals beneath the evaporator and briskly stirring the syrup by means of paddles 8 or 10 inches wide. When the sirup reached the density above indicated it was drawn off into wooden tubs, the fire having previously been drawn from beneath the evaporator.

It is doubtless true that many failures result in securing a crystallizable sirup even from good juice, owing to the operations of pressing of the cane, defecation, and evaporation being too much protracted. In order that those wishing to enter upon this industry may know what is practically attainable, even with common appliances, the following data are given.

In experiment No. 3, 2,107 pounds of topped stalks of Early Amber cane were pressed by the mill in 3½ hours, yielding 975 pounds of juice. The time required for heating the juice, defecation with lime, and evaporation to sirup was 5¾ hours. In order that the inferior character of the material supplied for these experiments might be known, specimens were taken from the several lots of stalks in experiments Nos. 1, 2, 3, 4, and it was found that the average weight of the stalks in these lots was four ounces each.

In most of the experiments above recorded the juice was raised to the temperature of 82° C. (180° F.), and then neutralized with milk of lime, but several experiments were made to learn the effect produced by neutralization with lime at different temperatures.

In experiment No. 4 the juice was divided into two portions, and the lime was added to the one portion at 40° C. (104° F.); to the other portion at 25° C. (77° F.), and the portions were separately evaporated to sirup.

In experiment No. 13 the lime was added directly after the juice was obtained from the mill, the temperature being 16° C. (61° F.).

In experiment No. 18, the lime was added at 80° C. (176° F.).

In the above-mentioned experiments the results were entirely satisfactory, and seem to indicate that the neutralization by means of lime may be effected at any stage below 82° C. No experiments were made in neutralizing at higher temperature than 82° C.

An experiment was also made to determine whether splitting the canes before they were passed through the mill would increase the percentage of juice obtained from the stalks. One hundred pounds of butt ends of Honduras sorghum were split lengthwise and then passed through the mill. Another parcel of one hundred pounds of butts of the same variety of sorghum, equal in all respects to the previous lot, was passed through the mill without splitting them. The results obtained were as follows: Percentage of juice obtained from split stalks, 54 per cent.; percentage of juice obtained from unsplit stalks, 57 per cent., from which it would appear that in this case, at least, the previous splitting of the stalks occasioned an appreciable loss in juice.

In plate 27 the apparatus used in these experiments is figured, showing the relative position of mill, pans, &c.

Two pans only are represented as being in use, viz: the defecating pan upon the left hand in the wood-cut and the evaporator upon the right hand. The stop-cocks by which the contents of the defecating pan are removed is not shown in the plate, being concealed by the small evaporator in front. A space of about two feet separates the brick work underneath the several pans, permitting one to pass easily about them.

The apparatus represented in the rear is used for making sulphurous acid solution, and consists of a small-sized hot water tank for kitchen range, about 40 inches long and 10 inches diameter. Into this powdered charcoal and oil of vitriol are put, and the sulphurous gas is passed through iron pipes into a wash-bottle containing oil of vitriol, and from thence into a barrel nearly filled with water. A safety tube is connected with the wash-bottle to prevent any possible rushing back of the water into the generator in case of the withdrawal of the heat. By this apparatus a barrel or two of the solution may be made in a short time and at an expense not over 75 cents per barrel. For two barrels there would be required 75 pounds of oil of vitriol and 7 pounds of powdered charcoal.

A few of the experiments made give a reasonable basis for estimating the probable yield of sirup and sugar to the acre; and, therefore, an approximate estimate of the cost of producing sugar.

Below is a tabulated result of a few of the experiments from stalks grown upon the grounds of the department. These stalks were grown in rows 3 feet apart, and in drills, and although a good crop, there is no doubt but that upon good land the estimated yield to the acre could be obtained:

	Pounds stalks from acre.	Sirup obtained.	Sirup, juice at best.	Sirup, juice 70 per cent.
Chinese sorghum	38, 600	2, 096	2, 397	3, 673
Liberian sorghum	33, 727	2, 472	2, 609	3, 783
Early Amber sorghum	32, 415	2, 100	2, 615	3, 661
Honduras sorghum	66, 151	3, 652	5, 168	7, 537
Pearl millet	65, 000	1, 846	3, 128	4, 865
Field corn	27, 240	1, 166	....	1, 807

The first and second columns give the results actually secured, but the several juices were not in their best condition as compared with the results given in the first table. The third column is the amount of sirup the same weight of stalks would have yielded had they been cut at the proper time. The juice obtained from the stalks by the imperfect means at command of the department was little more than half the amount present in the stalks.

The fourth column represents the results attainable by the use of a mill that would give 70 per cent. of juice from the stalks; a result which is possible, and which is claimed by manufacturers of mills.

There is no doubt but that, when the present industry shall have secured the employment of the capital and scientific ability which has developed the beet-sugar industry, even these results, which may appear extravagant to many, will be assured.

Although, as has been stated, these sirups were obtained from stalks in which the maximum content of sugar had not yet been developed, they did, however, all crystallize well, and all yielded excellent sugar.

At the present the sugar has been separated from but the Chinese sorghum sirup, which yielded in the first crop of crystals 54.7 per cent. of its weight in sugar; the Early Amber sirup, which yielded 47.5 per cent. of sugar; and from the field-corn sirup, which yielded 39.3 per cent. of sugar. This latter experiment is worthy of especial mention, since the result secured is not only most surprising, but contrary to an almost universal belief. The corn-stalks used were of three varieties: Lindsay's Horse Tooth, Improved Prolific, and White Dent; three coarse-growing white field corns. The stalks grew in drills 3 feet apart, and about 9 or 10 inches apart in the drill. The ears were plucked after they had thoroughly ripened, and the husks were dead and dry. The corn was plump and sound, and yielded at the rate of 69.1 bushels of shelled corn (56 pounds to the bushel) to the acre. The stalks were then topped, stripped, and crushed, and the juice proved to be the best juice yet obtained from corn-stalks, at any period of growth or of any variety.

Below are given the results of the examination of the stalks of Egyptian sugar-corn, Honduras and Early Amber sorghums, and the leaves from the same. This examination was made for the purpose of determining the loss of sugar in the method employed in its extraction, also to determine the relative nutritive value of the leaves and stalks, pressed and unpressed. The stalks selected were split lengthwise, so that a fair average might be taken, and one-half was dried thoroughly without pressing, and the other half was passed through the mill, and the bagasse, or pressed stalks, carefully saved and dried.

Leaves, stalks, and bagasse from corn and sorghums

	Weight fresh.	Weight bagasse.	Weight juice.	Per cent. juice.	Weight dry.	Per cent. water.
Egyptian sugar-corn, leaves	380	......	......	......	116.6	67.3
Egyptian sugar-corn, one-half of 4 stripped stalks, unpressed	832	......	......	......	126.0	84.9
Egyptian sugar-corn, one-half of 4 stripped stalks, pressed	875	460	415	47.43	99.0	88.7
Honduras sorghum, leaves	432	......	......	......	100.8	76.7
Honduras sorghum, one-half of 2 stripped stalks, unpressed.	1,428	......	......	......	285.3	80.0
Honduras sorghum, one-half of 2 stripped stalks, pressed	1,390	724	666	47.91	222.7	84.0
Early Amber sorghum, leaves	399	......	......	......	99.7	75.0
Early Amber sorghum, one-half of 3 stripped stalks, unpressed.	651	......	......	......	157.9	75.7
Early Amber sorghum, one-half of 3 stripped stalks, pressed.	905	458	447	49.39	147.8	83.7

A determination of the proximate constituents of the dried leaves, stalks, and bagasse is given below, from which it will appear that there still remains a large amount of sugar in the bagasse which the process employed failed to remove from the cane or stalks, also that the per cent. of starch compounds is greater in the pressed than in the unpressed stalks, and that the percentage of nitrogenous matter remains nearly the same. Since the nutritive value of the pressed stalks is nearly if not quite equal to that of the umpressed stalks, weight for weight, and as they are left in a mechanical condition suitable for their preservation as green fodder by the system of ensilage, it would appear desirable that experiments be made leading to their utilization for this purpose.

Proximate analyses of stalks, bagasse, and leaves of sweet corn and sorghum, calculated to the dry substance.

	Unpressed stalks, Early Amber sorghum.	Unpressed stalks, Honduras sorghum.	Unpressed stalks, Egyptian sugar-corn.	Bagasse of Early Amber sorghum.	Bagasse of Honduras sorghum.	Bagasse of Egyptian sugar-corn.	Leaves of Early Amber sorghum.	Leaves of Honduras sorghum.	Leaves of Egyptian sugar-corn.
Organic acid, chlorophyll, color.	7.36	5.39	2.85	1.47	2.01	1.11	1.46	3.29	1.48
Wax	.94	.33	.44	.35	.84	.40	5.05	1.67	.54
Brown resin	6.98	6.00	8.11	5.11	3.53	5.75	7.91	6.67	5.20
Sugars	34.73	38.14	26.01	19.36	21.77	10.08	8.58	9.37	8.21
Gum	2.14	1.57	1.38	2.04	2.20	1.33	3.82	2.78	4.54
Starch isomers	20.34	17.67	22.44	31.46	26.27	23.16	14.49	21.22	24.77
Albuminoids	4.95	4.81	6.90	3.96	3.87	6.04	13.14	10.43	11.34
Alkali extract, by difference.	....	5.15	6.09	13.35	15.10	22.26	12.08	11.98	12.65
Crude fiber	16.01	16.48	19.82	19.10	20.66	25.00	17.98	18.51	20.83
Ash, by ignition	6.55	4.46	5.96	3.80	3.75	4.87	15.49	14.08	10.44
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

By reference to the two preceding tables, it will be seen that a very large percent age of the sugar was lost by the method employed in its production.

The amount of sugar in the Early Amber cane, dry, is to the amount present in the Early Amber bagasse, dry, as 100 is to 55.74.

In Honduras cane, dry : Honduras bagasse, dry : : 100 : 57.08.

In Egyptian sugar-corn, dry : Egyptian sugar-corn bagasse, dry : : 100 : 38.75.

As will be seen from these analyses—

	Per cent. sugar.
The Honduras cane, fresh, contained	7.62
The Early Amber cane, fresh, contained	8.42
The Egyptian sugar-corn, fresh, contained	3.94

while the sugar remaining in the bagasse, calculated to the fresh cane which produced these bagasses, gave as follows:

	Per cent. sugar.
Honduras sorghum	3.49
Early Amber sorghum	3.16
Egyptian sugar-corn	1.14

In other words, it will appear that there was occasioned a loss of—

46.4 per cent. of the sugar present in Honduras sorghum.

37.4 per cent. of the sugar present in Early Amber sorghum.

28.9 per cent. of the sugar present in Egyptian sugar-corn.

The importance, therefore, of a good mill cannot be overestimated, and it is desirable that efforts be made to devise some process by which results approximating those obtained in the extraction of sugar from beets shall be attained, since it is obvious that should the beet-sugar industry be conducted in so wasteful a manner as is the production of sugar from cane or from sorghum, this important industry could not survive a year, even in those countries most favorably circumstanced in regard to the production of beet sugar.

For convenience the following results which were obtained last year are appended, since these experiments were only confirmed this year, but the results have not been tabulated.

In the experiments made with corn-stalks the stalks were invariably stripped, the tops being cut off at about the second joint. The percentage of stripped stalks, leaves, and tops is given in this table:

Corn-stalks.	Per cent. of stripped stalks.	Per cent. o leaves and tops.
No. 1	67. 57	32. 4
No. 2	58. 69	31. 3
Nos. 3 and 4	67. 46	32. 5
Average	67. 91	32. 0

In those cases where the sorghum was stripped and topped the following percentage of stripped stalks and of leaves and tops was obtained:

Sorghum.	Per cent. of stripped stalks.	Per cent. of leaves and tops.
No. 5	72. 67	27. 3
No. 6	72. 55	27. 4
Average	72. 61	27. 3

On account of the trouble in stripping the stalks, experiments were made with stalks unstripped, the tops alone being removed, and these experiments appear to prove that this troublesome operation of stripping may be avoided without any diminution of the amount of juice or of sugar obtained therefrom.

Below are the results obtained from stripped and unstripped sorghum, calculated to the raw stalks used.

By raw stalks is meant the stalks as they were cut in the field, leaves, tops, and all

	Average per cent. of juice to raw stalks.	Average per cent. sirup in juice.
Stripped sorghum, two experiments	35. 02	15. 0
Unstripped sorghum, five experiments	40. 60	15. 47

From the above it will be seen that not only was an increased amount of juice obtained, but that this juice gave an increased percentage of sirup, and there appears nothing unusual in the treatment of this juice from the unstripped cane, nor was there any appreciable difference in the readiness of the sirup to crystallize, nor in the character of the sugar finally obtained.

Although perhaps further experiments are desirable before considering this point as settled, it would appear from the above that not only was stripping unnecessary, but that it really involved a loss in the amount of sugar to be obtained; at least the above results indicate a difference of twenty per cent. increase in product in favor of the unstripped cane. It is not improbable that the above result is due to the fact that the leaves in passing through the mill tended to fill up the interstices between the compressed cane, and thus prevented the expressed juice from flowing through between the rolls with the bagasse. In case of discoloration by action of moisture or other causes, it will, however, be advisable, and probably necessary, to strip the stalks.

Several experiments were also made with both corn-stalks and sorghum to determine the relative value of the upper and lower half of the stalks, with the results given in the following table:

	Percentage of juice to stalks.	Specific gravity of juice.	Percentage of sirup in juice.
Corn-stalks, butt ends, No. 3	29.04	1053	14.62
Corn-stalks, top ends, No. 4	19.94	1050	13.46
Sorghum, butt ends, No. 8	47.49	1059	16.41
Sorghum, butt ends, No. 10	41.49	1062	16.47
Sorghum, top ends, No. 9	43.16	1057	14.70
Sorghum, top ends, No. 11	34.09	1059	14.26

Nos. 8 and 9 were the butts and tops of the same stalks, and were cut just after a rain, as were also Nos. 10 and 11, from which the rain had evaporated, and the difference in yield of juice and sirup between butts and tops is nearly constant. The increase in specific gravity of the juice from butts over that from the top is also worthy of notice.

From the above table the conclusion from the average results is, that the proportion, by weight, of sugar in the lower half of the stalk is to the sugar in the upper half as follows: Corn butts to corn tops as 159 to 100; sorghum butts to sorghum tops as 131 is to 100. As will be seen by reference to the first table, the stalks of both corn and sorghum in the above experiment were divided almost equally by weight into butts and tops, so that the above proportion fairly represents the proportion of yield of sugar in the upper and lower half of the cane. There was a marked difference in the appearance of the juice as it flowed from the mill (that from the butts being lighter in color, especially in the experiments with corn), but after clarification no appreciable difference could be observed, nor was there any difference in the product except the quantitative one above mentioned, which was, however, a marked difference. Also, there was a marked difference in granulation in favor of the juice from the butts.

The experiments of this year (1879) doubtless explain some of the results of the previous year; since it is probably true that, owing to immaturity, the tops had not yet attained their maximum content of sugar. A study of the previous tables giving results of the analysis of sorghums shows that up to a certain period the lower half of the cane is the best, but that this does not remain true of the sorghum, as it does of the sugar-cane in Louisiana, since the sorghum does have time to completely mature, which is not true of the sugar-cane in our country.

In the following table there have been calculated from the results given of the experiments in the making of sugar the following:

1st. The percentages of the sugar present in the juices operated upon, which were obtained in the sirup.

2d. The percentage of crystallizable sugar (sucrose) present in the juices which was obtained in the sirup.

3d. The percentage of uncrystallizable sugar (glucose) present in the juices, which was obtained in the sirup.

4th. The percentage of crystallizable sugar present in the juices, which was inverted by the process of manufacture.

5th. The percentage of uncrystallizable sugar (glucose) destroyed during the process of manufacture.

The presence of the same relative proportions of crystallizable and uncrystallizable sugar in a sirup to those present in the juice from which this srup has been prepared, by no means implies that there has been no inversion of the crystallizable sugar; for the destructive action of an excess of lime upon glucose is well known and is not unfrequently made available in the production of sugar. Hence it not unfrequently happens that the relative quantity of crystallizable sugar in the sirup may be greatly in excess of that present in the juice, even after a large quantity of the crystallizable sugar has been destroyed by inversion. It is only possible then to determine the character of the changes which have taken place in the sugars during the process of manufacture, by quantitatively determining the amounts of sucrose and glucose in the juices and in the sirups prepared from them.

Since, obviously, this is a question of the greatest practical importance, as bearing upon the profitableness of the production of sugar from corn-stalks or sorghum, the tables following will be studied with interest by those engaged in this production.

As will have been observed in the previous table, there is a constant but not uniform discrepancy between the polarization of the sirups and the amount of crystallizable sugar found present by analysis.

Almost invariably the amount of sucrose found present is somewhat in excess of the amount indicated by the polariscope, and this variation is such as to forbid any supposition that it is the result of error in observation or in analytical work.

This explanation may be found by consulting the following tables, by which it appears that, although there is generally about the same amount of glucose in the sirups relative to the amount present in the juice (averaging 97.1 per cent.), there is still evidence of the destruction of an average of 35 per cent. of the glucose. This destruction of glucose appears to be compensated, in part, by the inversion of a certain portion of the crystallizable sugar, and this inverted sugar possesses such action upon the polarized ray as to render the results of the polariscope practically worthless.

Practically, it appears that the proportion of crystallizable sugar present in the juice, which may be obtained in the sirup, depends greatly upon the condition of the stalks when worked. For, as will be seen, the average amount secured in all these experiments was but 77.1 per cent., still in those sirups prepared from canes which were in the proper condition the amount was over 90 per cent. of the crystallizable sugar present in the juice operated upon. (See experiments Nos. 6 and 7.) It is not improbable that even better results may be secured after further experiments shall have perfected the process of manufacture; but in view of the fact that such results have been attained with such crude and simple apparatus as that employed in the experiments here recorded, this result is highly gratifying.

We may hope then to secure in sirup 90 per cent. of the crystallizable sugar present in the juice operated upon.

Number.	Per cent. of sugars in sirup of amount present in juice.	Per cent. of sucrose in sirup of amount present in juice.	Per cent. of glucose in sirup of amount present in juice.	Per cent. of sucrose inverted of amount present in juice.	Per cent. of glucose destroyed in process of making.
1					
2	82.3	66.7	138.3	33.3	0.0
3	74.7	66.1	102.1	33.9	31.8
4	83.3	76.0	106.0	24.0	18.0
5	85.1	80.2	107.8	19.8	12.0
6	94.4	89.1	120.9	10.9	
7	92.9	91.7	103.6	8.3	4.7
8	77.4	57.7	127.7	42.3	14.6
9	89.5	87.1	96.5	12.9	16.4
10	91.8	95.7	90.7	4.3	13.6
11	79.0	69.7	91.2	30.3	39.1
12	82.1	79.8	91.3	20.2	28.9
13	80.4	67.5	114.5	32.5	18.0
14	86.4	68.9	98.6	31.1	32.5
15	95.6	98.7	110.6	1.3	
16					
17	87.4	83.3	96.7	16.7	20.0
18	75.5	68.8	103.5	31.2	27.7
19	71.8	69.7	80.4	30.3	49.9
20	76.1	77.2	71.3	22.8	51.5
21	87.2	82.9	96.8	17.1	20.3
22	86.3	85.6	87.2	14.4	27.2
23	90.8	69.3	98.3	30.7	32.4
24					
25	102.2	102.7	102.0		
26	58.3	29.7	25.8	70.3	144.5
27	79.2	28.8	37.5	71.2	133.7
28					
29	96.1	98.5	92.8	1.5	8.7
30	85.4	79.2	96.1	20.8	24.7
31	118.5	110.1	133.2		
32					
33	84.9	77.5	93.7	22.5	28.8
Average	85.5	77.1	97.0	24.2	34.7

The results obtained in the experiments made with stalks from Stowell's Evergreen Sweet Corn are most remarkable and demand explanation. It will be seen that the juice obtained from these stalks gave in the laboratory excellent results, and promised a sirup of fine quality. By reference to the tables it will be seen, however, that these sirups (see experiments Nos. 26 and 27) were wholly abnormal and very disappointing. These stalks were cut in Frederick, Md., October 11, packed in a close car, and, through an oversight, allowed so to remain during oppressively hot weather until the 15th. They were worked up on the 16th, 17th, and 18th. Upon their arrival at Washington they were found so heated as to render their removal from the car even difficult, and yet, as will be seen, the juice expressed from them appeared of excellent quality, but every attempt to produce from it a crystallizable sirup failed, and an analysis of the sirup showed that a very large percentage of the sugar had been inverted (in experiments Nos. 26 and 27), and that the destruction of glucose in the sirup had been unusually large, while the amount of crystallizable sugar present in the juice, and recovered in the sirup, was less than 30 per cent.

A few of the results attained appear to be only explicable upon the supposition that there have been slight errors in analysis, but revision of the work fails to reveal such errors, and the results are given in full without omission, hoping that future investigation may enable us to solve difficulties which at present appear irreconcilable.

Comparison of the upper and lower halves of sorghum-canes.

	Per cent.
Average per cent. of water in 17 specimens of Chinese sorghum .... tops ..	73.05
Average per cent. of water in 16 specimens of Chinese sorghum ...... butts ..	74.46
Average per cent. of water in 20 specimens of Honduras sorghum ..... tops ..	72.57
Average per cent. of water in 20 specimens of Honduras sorghum ... butts ..	76.15
Average per cent. of water in 23 specimens of Liberian sorghum ...... tops ..	71.67
Average per cent. of water in 23 specimens of Liberian sorghum .... butts ..	75.22
Average per cent. of water in 22 specimens of Early Amber sorghum ... tops ..	72.73
Average per cent. of water in 22 specimens of Early Amber sorghum . butts ..	72.13
Average per cent. of juice from 10 specimens of Chinese sorghum ..... tops ..	45.17
Average per cent. of juice from 10 specimens of Chinese sorghum ... butts ..	49.89
Average per cent. of juice from 16 specimens of Honduras sorghum ... tops ..	42.88
Average per cent. of juice from 17 specimens of Honduras sorghum .. butts ..	45.44
Average per cent. of juice from 13 specimens of Liberian sorghum ..... tops ..	42.63
Average per cent. of juice from 13 specimens of Liberian sorghum ... butts ..	44.50
Average per cent. of juice from 11 specimens of Early Amber sorghum .. tops .	46.68
Average per cent. of juice from 11 specimens of Early Amber sorghum . butts ..	50.58
Average specific gravity of juice from 17 specimens of Chinese sorghum, tops	1.0725
Average specific gravity of juice from 17 specimens of Chinese sorghum, butts	1.0708
Average specific gravity of juice from 21 specimens of Honduras sorghum, tops	1.0602
Average specific gravity of juice from 21 specimens of Honduras sorghum, butts	1.0584
Average specific gravity of juice from 24 specimens of Liberian sorghum, tops	1.0753
Average specific gravity of juice from 24 specimens of Liberian sorghum, butts	1.0730
Average specific gravity of juice from 22 specimens of Early Amber sorghum, tops	1.0765
Average specific gravity of juice from 22 specimens of Early Amber sorghum, butts	1.0771
Average per cent. of solid matter in juice from 16 specimens of Chinese sorghum .... tops ..	16.21
Average per cent. of solid matter in juice from 17 specimens of Chinese sorghum .... butts ..	16.81
Average per cent. of solid matter in juice from 19 specimens of Honduras sorghum .... tops ..	13.85
Average per cent. of solid matter in juice from 20 specimens of Honduras sorghum .... butts ..	13.82
Average per cent. of solid matter in juice from 23 specimens of Liberian sorghum .... tops ..	16.91
Average per cent. of solid matter in juice from 22 specimens of Liberian sorghum .... butts ..	16.71
Average per cent. of solid matter in juice from 19 specimens of Early Amber sorghum .... tops ..	17.59
Average per cent. of solid matter in juice from 21 specimens of Early Amber sorghum .... butts ..	16.75

	Per cent.
Average per cent. of water in tops, 79 specimens	72.45
Average per cent. of water in butts, 79 specimens	74.51
Average per cent. of juice from tops, 50 specimens	43.96
Average per cent. of juice from butts, 51 specimens	46.90
Average per cent. of solids in juice from tops, 77 specimens	16.18
Average per cent. of solids in juice from butts, 80 specimens	16.92
Average specific gravity of juice from tops, 84 specimens	10.71
Average specific gravity of juice from butts, 84 specimens	10.70

From the above comparison it will appear that there exists no marked difference in the amount of juice present in the upper and lower halves of the canes, nor in the quality of this juice as indicated by either the relative specific gravities or the total amount of solid matter present in the juices.

But by reference to the previous tables, giving the results in detail, the fact will appear in the case of each of the sorghums examined that, during the early stages of development of these plants, the total sugars present in the juices is comparatively low, often not one-third of the maximum afterwards found in the plant, and consequently the amount of sirup possible to be made from this immature cane is proportionately less than that which the same stalks would yield when fully matured.

It will also appear that, during this early and immature state of the plant, the relative amount of crystallizable sugar (sucrose) as compared with the total sugars present is much greater in the lower half of the canes. This condition remains, apparently, until the seed has reached the milky state, at which time the juices in both parts of the plant appear to be of equal value. But it must not be understood that the maximum content of sugar in the plant has been reached at this period of development, since, as will be seen by the tables, this is far from the fact.

From this period in the plant's development until the perfect ripening of the seed, the juices appear to uniformly increase in their content of crystallizable sugar, and to decrease in their content of uncrystallizable sugar.

Still later in the history of the plant there appears a slight deterioration in the quality of the juice from the lower half of the stalk, and it is found generally to be somewhat inferior to the juice from the upper half.

It appears probable that this deterioration of the juice from the lower part of the cane marks the incipient stages of death and the ultimate decay of the plant, the roots and leaves failing in their office to supply the full amount of nourishment which the plant requires. It begins to feed upon itself, so to speak, and it is to be observed that at this period the off-shoots from the upper joints of the stalk begin a vigorous growth and appear to live as parasites upon the parent stalk.

It will appear also that at the first examinations the specific gravity of the juices from the lower half of the cane is almost invariably greater than that of the juices from the upper halves, and that an equality of specific gravity appears to indicate an equality between the juices in their content of sugar not only, but in its relative proportions of sucrose and glucose.

Proximate analyses have been made of the seed of two varieties of sorghum, the early amber and the Chinese, the results of which are given below. It will be seen that this seed differs but little in composition from the other cereals, and closely resembles corn, and it will doubtless prove valuable as food for farm stock.

	Sorghum seeds.	
	Early amber.	Chinese.
Moisture	10.57	9.93
Ash	1.81	1.47
Fat	4.60	3.95
Sugars	1.91	2.70
Albumen, insoluble in alcohol	2.64	2.64
Albumen, soluble in alcohol	7.34	6.90
Gum	1.10	.72
Starch, color, &c	68.55	70.17
Crude fiber	1.48	1.52
	100.00	100.00

Moisture was estimated from loss by drying at 105° C. Ash, by simple ignition; total albuminoids from total nitrogen multiplied by 6.25. Under "sugars" is given that portion of the 80 per cent. alcohol extract which was found soluble in water. The insoluble portion of this alcohol extract included a little red coloring matter, but otherwise seemed to be identical with the "zein" of maize. Gum was extracted by water, after use of ether and alcohol. Fat was extracted directly from the sample by absolute ether; it was yellowish, semi-solid, and very much resembled the fat similarly extracted from corn. Starch, color, &c., were determined by difference. In early amber there was found 64.05 per cent., and in Chinese sorghum 64.74 per cent. of starch by titration, with Fehling's solution of an acid extract made after extraction with ether, alcohol, and water.

Crude fiber is that portion, ash free, which still remains insoluble after treatment of the sample with ether, alcohol, water, dilute hydrochloric acid, and dilute potassic hydrate. It is usually white or slightly gray, and free from nitrogen.

Proximate analyses have also been made of the scum and sediment obtained in defecating the juice, with a view of throwing light upon the chemical character of this important process.

The results of these analyses are given below.

	Liberian lime precipitate.	Honduras lime precipitate.	Honduras skimmings.
Moisture	9.77	7.69	5.72
Ash	21.69	7.00	14.30
Chlorophyll and wax	17.60	8.95	14.44
Sugars	10.80	43.96	15.06
Resins and trace albumen	—3.61	3.26	5.08
Gum	6.02	11.40	11.10
Albuminoids	22.58	4.55	8.05
Humus-like substances, diff	—5.73	12.71	5.58
Crude fiber	2.20	.48	5.49
Starch isomers	Trace.	Trace.	15.18
	100.00	100.00	100.00

The large amount of ash in Liberian lime precipitate and Honduras skimmings is due to the presence of considerable clay, which had been used to hasten the clarification of the juice. There was little or no clay present in Honduras lime precipitate. The claying seems mechanically to have carried down a large proportion of the albumen in the Liberian lime precipitate.

The very great difference in these waste products is probably due almost wholly to differences in the manipulation of the juices.

Very probably there exists in lime precipitates a combined organic acid; this will be investigated in the future.

Whoever may detect error in the methods employed, or in the results stated, will confer a favor by mentioning the same.

It is certainly most desirable that these experiments be continued upon a larger scale, and with at least a dozen varieties of sorghum and an equal number of varieties of sweet, yellow, and white corn.

At least an acre of each variety should be grown, and the development of each should be watched through the season, and when the proper time for working up the crop has come, let the acre be worked up for sugar. Such an experiment would require little outlay and be productive of invaluable results. It would require at least three or four assistants additional in the chemical laboratory to attend to the continued analyses of the canes, and would necessitate a somewhat larger apparatus for working up the crop.

The correspondence addressed to this division upon this subject of sugar has steadily increased until it requires nearly all the time of one assistant to attend to it.

THE PERMANGANATE PROCESS FOR THE ESTIMATION OF SUGARS IN JUICES.

1. *Preparation of the juice.*

Usually two stalks were selected for analysis. Their maturity, as shown by the development of blossoms, seeds, and the color and condition of the glumes, was recorded. Then were noted—

a. The weight of the unstripped stalks.

b. The weight of the stripped and topped stalks, and, by difference, the weight of leaves and tops.

c. The average length and diameter of the stripped stalks.

These stripped stalks were then divided so that tops and butts were of equal weight. Then was found—

d. The average length each of tops and butts. The tops and butts were then separately analyzed. Each by itself was cut finely with a hatchet, and then bruised in an iron mortar. The bruised mass was then placed in a small bag, and submitted to a heavy pressure in an ordinary iron press.

The expressed juice was collected and weighed, and the percentage calculated to the unstripped stalks taken.

The juice thus obtained usually was greenish from the presence of chlorophyll. As the plant matured, the color of the juice inclined to amber, and in perfectly ripe stalks (especially of the Early Amber variety) the color was red, from the presence, in the central portion of the stalk, of a red coloring matter sparingly soluble in ether, readily dissolved by 80 per cent. alcohol.

The specific gravity of the juice was determined usually by a piknometer. It was found that the readings given by an accurate hydrometer accorded well with the specific gravity indicated by weight, if the juice was previously allowed to stand for about half an hour, to allow included air to escape.

A weighed portion of the juice was dried, at a heat not exceeding 100° C, until two successive weights showed but little variation; the percentage of residue thus found was stated as *total solids in juice*. These figures can be regarded only as fair approximations, for chemists are well aware of the difficulties attending the perfect desiccation of saccharine juices. In this connection, however, the results are valuable as checks upon the sugar determinations.

For determination of sugars in the juice 100 c. c. were taken, and made in every case to 125 c. c. by addition of solution of subacetate of lead and water. Among other substances precipitated by the treatment were chlorophyll, albumenoid matter, gum, and lead salts of the inorganic acids of the ash.

The liqid was filtered perfectly clear through dry paper, and was sometimes colorless and sometimes amber. Every 10 c. c. of this liquid represented 8 c. c. of the original juice.

For the determination of inverted sugar, 10 c. c. of this filtered liquor were taken, and for sucrose 5 c. c.

The portion for glucose was treated with considerable excess of Fehling's solution, and carefully heated on the water-bath, a thermometer being inserted in the liquid, which was not allowed to rise above 75° C. At this temperature perfectly pure sucrose does not reduce Fehling's solution in the least.

The portion for sucrose was inverted by boiling half an hour with slight excess of dilute hydrochloric acid. The inverted sugar thus formed was then treated with large excess of Fehling's solution, exactly as above described, except that it was not necessary to keep the temperature lower than the heat of the water-bath (100° C.).

The precipitated red suboxide of copper was then thoroughly washed with hot water by decantation and filtration (without aspiration usually) through fine paper. It was then dissolved in an acid (sulphuric) solution of ferric sulphate, and the amount of ferrous salt determined by titration with potassium permanganate.

This method for determining glucose depends upon the following facts:

1. That two molecules (360 parts by weight) of glucose ($C_6\ H_{12}\ O_6$) will reduce from Fehling's solution five molecules of cuprous oxide ($5\ Cu_2\ O$).

2. That the five molecules of cuprous oxide thus precipitated will reduce in acid sol. five molecules of ferric sulphate ($Fe_2\ (S\ O_4)_3$) to form ten molecules (1,520 parts by weight) of ferrous sulphate ($Fe.\ S\ O_4$) as is explained by the following equation:

$$\left\{\begin{matrix} 5\ Cu_2\ O \\ 715 \text{ parts} \end{matrix}\right\} + \left\{\begin{matrix} 5\ Fe_2\ (S\ O_4)_3 \\ 2{,}000 \text{ parts} \end{matrix}\right\} + \left\{\begin{matrix} 5\ H_2\ S\ O_4 \\ 490 \text{ parts} \end{matrix}\right\} = \left\{\begin{matrix} 10\ Cu\ S\ O_4 \\ 1{,}595 \text{ parts} \end{matrix}\right\} + \left\{\begin{matrix} 10\ Fe\ S\ O_4 \\ 1{,}520 \text{ parts} \end{matrix}\right\} + \left\{\begin{matrix} 5\ H_2\ O \\ 90 \text{ parts} \end{matrix}\right\}$$

The ten molecules of ferrous sulphate thus formed will decolorize one molecule (316.2 parts by weight) of potassium permanganate ($K_2\ Mn_2\ O_8$), thus:

$$\left\{\begin{matrix} 10\ Fe\ S\ O_4 \\ 1{,}520 \text{ parts} \end{matrix}\right\} + \left\{\begin{matrix} K_2\ Mn_2\ O_8 \\ 316.2 \text{ parts} \end{matrix}\right\} + \left\{\begin{matrix} 8\ H_2\ S\ O_4 \\ 784 \text{ parts} \end{matrix}\right\} = \left\{\begin{matrix} 5\ Fe_2\ (S\ O_4)_3 \\ 2{,}000 \text{ parts} \end{matrix}\right\} + \left\{\begin{matrix} 2\ Mn\ S\ O_4 \\ 302 \text{ parts} \end{matrix}\right\} + \left\{\begin{matrix} K_2\ S\ O_4 \\ 174.2 \text{ parts} \end{matrix}\right\} + \left\{\begin{matrix} 8\ H_2\ O \\ 144 \text{ parts} \end{matrix}\right\}$$

By following this explanation, it appears that two molecules of glucose are exactly represented by one molecule of potassium permanganate, as will appear from the following, by omitting the second and third members of the series. Thus:

$$\left\{\begin{matrix} 2\ C_6\ H_{12}\ O_6 \\ 360 \text{ parts} \end{matrix}\right\} = \left\{\begin{matrix} 5\ Cu_2\ O \\ 715 \text{ parts} \end{matrix}\right\} = \left\{\begin{matrix} 10\ Fe\ S\ O_4 \\ 1{,}520 \text{ parts} \end{matrix}\right\} = \left\{\begin{matrix} K_2\ Mn_2\ O_8 \\ 316.2 \text{ parts} \end{matrix}\right\}$$

In other words, 316.2 parts by weight of potassium permanganate are equivalent to 360 parts of glucose, or one part of permanganate corresponds to 1.1385 parts of glucose. If, then, the amount of permanganate decolorized be multiplied by 1.1385 it will correctly represent the amount of glucose present. So much for the theoretical explanation. In practice it is found that each chemist must determine for himself his titration error by estimations made upon sugar of known purity.

This individual error is due to the difficulty in determining the exact end reaction; experience has shown, in the course of this work, that the point where the color of the permanganate barely appears in the rapidly agitated liquid is nearly identical with the true end reaction. Some operators carry the titration a little further until a faint rose tint is permanent for about two seconds. Each man who has done this work has carefully determined his titration error, and all figures submitted have been corrected therefor. The iron solution works best if very strongly acidulated with sulphuric acid. The most convenient strength for the permanganate solution is 4.392 grams to the liter, equal to .005 grams glucose for each cubic centimeter.

In the earlier part of these determinations it was not considered necessary to thoroughly wash the precipitated suboxide of copper before dissolving it in the ferric sulphate solution. Carefully performed experiments, however, showed that washing was best, and that the results obtained on unwashed suboxide would equal those on the washed if multiplied by .9676 for glucose and by .9438 for sucrose.

As the results of much careful work it appears that, if the suboxide be well washed, and if each operator determines his titration error, the determination of glucose by this method is very accurate.

The amount of glucose found was divided by the weight of 8 c. c. of the juice analyzed for percentage of glucose. The sucrose was found by subtracting from the total glucose after inversion the amount originally present in 4 c. c. of the juice, and multiplying the remaining glucose by .95. The percentage was then calculated in the usual way.

Respectfully,

PETER COLLIER,
Chemist, Agricultural Department.

MACHINERY.

Replying to your inquiry relative to the different kinds of machinery for making sugar from sorghum, I would remark that the juices of the various kinds of sorghum examined by the department (and the same is true without doubt of all varieties of sorghum) are so nearly similar to the juice of the tropical sugar-cane (*Saccharum officinarum*) that the same machinery and the same processes will undoubtedly be as useful in the manipulation of the one as of the other.

Heretofore sorghum has been grown for the purpose of making sirup in almost every part of the country where corn would grow; and in this manufacture a certain class of machinery, known as sorgo-machinery, has become general. This machinery is simple and strong in structure, and as now made consists ordinarily of three rollers, which are either vertical or horizontal, and are driven by horse, steam, or other power. Having a capacity for work in proportion to the power employed and the size of the mill, and varying but little in construction, it is manufactured in all parts of the United States and can be obtained at low rates at almost any large machine-shop.

The cuts here presented in illustration of the leading classes of sugar-making machinery have been kindly furnished by two or three houses largely engaged in the manufacture; but machinery of like character is made in almost every county in the United States in which there is a large iron-working establishment. Whatever difference of opinion may exist relative to the comparative efficiency of the several mills and pans on the market must be decided by the individuals who wish to purchase. They will not and need not necessarily be confined to any special kind, as there are many desirable sorts for sale throughout the country. By way of comparison the illustrations embrace some that represent the primitive methods of sugar-making among the Hindoos and other nations.

The cost of a small outfit necessary to work up the product of the ten to fifty acres of sorghum that one or two farmers might raise in a neighborhood, would be from $150 to $500, while mills required in larger operations would, of course, necessitate a proportional increase in expenditure. The *plant* or apparatus commonly employed at this time in the manufacture of sorghum syrup consists of a small three-roller mill. for expressing the juice; one or more tanks for receiving it and heating it to a point where lime or other defecating agents may be used (if it be thought necessary to use them at all), and a shallow pan or two for evaporation. However, much fuller information on this subject than I can now give will be found in the proceedings of the convention of the Northwestern Sugar Growers' Association, before referred to.

In the practical manufacture of sugar, in a large way, from sorghum and corn-stalks, it will be found necessary, I have no doubt, to establish large central factories or mills, having the same relations to this industry as do the grist-mills of a neighborhood, to-day, to wheat and corn. Mills of this character should be capable of handling at least 500 acres of sorghum or corn during one season, and I am informed by manufacturers of machinery who have considered the subject with care that such mills may be built for a sum not exceeding $12,500, and that possibly this amount would also afford a margin for a fair working capital for the operations of a single season. This central factory would be able to work up not only the cane from 500 acres during a season, but also to rework into sugar the product of the small mills established at greater or less distances around it that had carried their operations no further than the manufacture of concentrated sirup, weighing, say, ten pounds to the gallon.

Probably it will be more profitable to the average farmer to simply convert the juice of his stalks into a sirup and sell it as such to a mill prepared for making sugar in a large way, with vacuum-pans and centrifugals, than it would be to work his cane into sugar himself. For although good sugar has been made during the past season by open-pan evaporation by small farmers in many parts of the country, and made at a profit, yet the time must come when the competition in the manufacture of sugar will be so great as to reduce the profits materially, and to demand the closest economy in all the various processes of cultivation and subsequent manipulation. Until, however, the supply shall begin to equal our home demand there will probably be a very fair profit to the average farmer with his small mill and open-pan evaporation in making sugar, molasses, and vinegar; for vinegar is one of the products of this industry which is of importance, the skimmings and other refuse making an excellent article that finds ready sale at remunerative prices.

The entire cost from the first breaking up of the land, and carefully counting every expenditure at the current cash prices of the country for labor and other things, the entire cost of production in the Western States, the past season, of a gallon of dense sirup, weighing say 13 pounds, did not exceed 16⅔ cents on an average. (It is quite possible to produce it at less cost.) These 13 pounds of sirup, if properly managed, should give from 6 or 8 pounds of sugar; and, if handled by the centrifugal, the sugar can be separated from the sirup at a fraction of one cent. per pound.

I am informed by Mr. Thoms, an experienced sugar boiler, employed last season at the Crystal Lake Sugar Works, Illinois, at which were made many thousand pounds of good sugar, that with trimmed cane delivered at the mill door, he can make and deliver the sugar at the mill for 1¼ cents per pound, a statement corroborated by Mr. Russell, of Janesville, Wis., late superintendent of the Crystal Lake Factory during the season of 1879.

The trimmed stalks can be bought for from $2 to $4 per ton delivered at the mill; and the farmer can very well afford to deliver them for this price, as he can raise from 15 to 30 tons per acre, and obtain besides a crop of seed equal in value to a fair crop of oats from the same number of acres, to say nothing of the large supply of excellent blade fodder. If we assume 20 tons of stalks per acre (and it is not too high an estimate for good land), the yield per acre would be from $60 to $80 delivered; and if the haul was not too long, this would be exceedingly profitable to the grower. If the haul should be so long as to preclude a profit, then it would be necessary for the farmer to have a small mill to reduce the juice to a dense sirup, as has been described, and to market it at the large factory in that condition.

Although a fair measure of success * has rewarded the efforts of many who were engaged, the past season, in the manufacture of sugar from sorghum, yet to obtain sugar uniformly and profitably from the juice of the various sugar-producing plants, under differing conditions of soil and seasons, experience is requisite as well as theoretic knowledge.

Instruction in this matter is of the utmost importance, and hence it is desirable that the Department of Agriculture should be authorized

* The following table is an epitome of the reports received by the department from those to whom the seed of the Early Amber cane was sent. Many of those reporting were entirely unaccustomed to the cultivation of this crop, and consequently were only partially successful. Others had the experience of some years to aid them, and from these the reports are uniformly favorable, and some remarkably favorable. A yield of at least 200 gallons of dense sirup per acre (worth 40 cents to 50 cents per gallon) it would seem reasonable to expect as the result of good seasons, good soil, good cultivation, and good milling.

State.	Average number gallons per acre.	Average value.	Number of people making sugar.	Price per pound.	Highest yield per acre.	Lowest yield per acre.
Alabama	122	$0 50	......	......	192	60
Arkansas	117	48	......	......	256	52
Colorado	116	90	......	......	124	109
California	196	50	1	......	200	192
Delaware	25	......	......	......	......	......
Dakota Territory	112	66	......	......	168	50
Florida	145	30	......	......	240	50
Georgia	104	48	......	......	192	42
Illinois	132	46	8	$0 10	325	40
Indiana	127	40	3	......	400	25
Indian Territory	127	75	......	......	200	82
Iowa	130	52	16	......	350	60
Kansas	114	49	7	......	300	25
Kentucky	119	39	2	......	244	31
Maryland	111	60	......	......	150	40
Michigan	166	51	2	......	480	75
Minnesota	138	56	5	......	376	43
Mississippi	111	49	......	......	500	32
Missouri	135	40	30	......	300	48
Nebraska	124	55	3	......	300	50
New Jersey	147	......	2	......	200	90
New York	175	75	2	......	214	136
North Carolina	163	57	3	......	176	40
Ohio	151	48	9	......	453	50
Pennsylvania	138	50	......	......	176	100
South Carolina	94	50	......	......	136	25
Tennessee	138	41	3	......	392	40
Texas	114	57	11	......	361	30
Utah Territory	117	62	1	......	150	98
Virginia	113	55	3	......	180	50
West Virginia	127	51	8	11	216	60
Wisconsin	149	54	17	......	260	60
	128	50	......	10.5	500	25

and empowered to make such experiments (at various central points, easily reached by those who are interested) as will practically instruct the people in all the various processes and machinery heretofore successfully used, and to discover, if possible, other and better methods of speedily obtaining the object in view, viz., the production of our own sugar and the consequent saving of the large sum annually paid for foreign sugar. The passage of Senate bill No. 1514 (referred to me) would enable the Department to institute important experiments in at least three localities that would go far to determine in a scientific manner the questions in the way of a speedy solution of the problem.

CONSUMPTION AND PRODUCTION.

Of your several inquiries there remains to be considered only the question of statistics relative to the consumption and production of sugar in the United States.

Perhaps I cannot make better reply to this inquiry than has already been made in my annual report for 1878. In that report the *consumption* from 1866 to 1878 inclusive for the entire country is given as follows:

	Pounds.		Pounds.
1866	1,012,799,904	1873	1,525,974,971
1867	870,526,017	1874	1,705,193,954
1868	1,195,120,413	1875	1,859,159,674
1869	1,309,847,125	1876	1,604,947,164
1870	1,306,202,065	1877	1,731,573,553
1871	1,327,456,300	1878	1,991,744,160
1872	1,565,760,616		

For the same years the *production* of cane sugar in the United States was as follows:

	Pounds.		Pounds.
1866	47,150,000	1873	102,922,700
1867	43,294,050	1874	134,504,691
1868	96,894,400	1875	163,418,070
1869	100,153,500	1876	190,672,570
1870	166,613,150	1877	147,101,941
1871	147,730,150	1878	257,094,160
1872	124,798,000	1879	210,670,000

In addition to this amount of sugar from cane there were produced, from 1866 to 1877 inclusive, 459,031,151 pounds of maple sugar.

The consumption of sugar for the year 1879 was within a small fraction of 40 pounds per capita of our population, being an increase of nearly 10 pounds per capita since the decade of 1860–'70 and of 15 pounds since the decade 1850–'60.

From these and other tables in our possession, it is found that over and above the amount of all sugars produced in the United States since 1849 we have consumed during the same period not less than eighteen hundred and odd millions of dollars' worth of foreign sugars and their allied products, or an amount of sugar more than equal in value to all the precious metals mined in the country since the discovery of gold in California, and nearly equal to the public debt at the present time. Estimating the population of the United States at 50,000,000, and multiplying this number by the pounds (40) per capita consumed in 1879, we have for the consumption of that year a total of 2,000,000,000 pounds. Of this amount 1,743,560,000 pounds, or more than 80 per cent., besides 38,395,575 gallons of molasses (the whole valued at $75,017,145, or, duty added, $114,516,745), were imported. To bring the vast amount of sugar imported into the country within more easy comprehension, we have only to imagine five vessels of nearly 500 tons each and loaded with sugar arriving daily at our ports each day in the year. To convey the whole amount consumed would require five trains of twenty cars each starting daily for one thousand days.

I have the honor to be, very respectfully,

WM. G. LE DUC,
Commissioner.

A.

ILLUSTRATIONS OF SUGAR PLANTS.

Of the following plates the first four represent varieties of sugar-cane grown, during the past season, on the grounds of the Department of Agriculture at Washington and used in the experiments of the Chemical Division, as detailed in Professor Collier's accompanying report. The drawings were made by a gentleman employed in the department. The designations given them are somewhat different from those current in some parts of the country, but are conformed to what are believed to be the most authoritative standards.

Plate I represents the Early Amber sugar-cane, the favorite variety with planters in Minnesota and the Northwest. What is now called the Minnesota Early Amber cane is claimed as an improvement upon the Early Amber varieties growing formerly in different parts of Minnesota, by Hon. Seth M. Kenny and Mr. C. F. Miller, of that State. Acting on the theory that cane in a high latitude will degenerate if grown continuously from its own seed, these gentlemen selected the finest specimens of seed from their own crops and sent them to a southern latitude to be grown. The seed product of this southern growth was returned to Minnesota. By this alternation of seed, and by other intelligent processes of culture, they have succeeded in establishing a new and permanent variety, which they claim to be more productive in weight of cane and to contain a higher per cent. of saccharine matter than any other grown in that State. This claim needs to be substantiated by more careful and extended observations before it can be said to be fully established.

Messrs. Kenny and Miller describe the Early Amber cane as presenting "the characteristics of both sorgo and imphee." By sorgo they mean the Chinese sorgo (Plate II), and by imphee, the White Liberian (Plate III), and its kindred African varieties. The Early Amber receives its name from its early ripening and from the bright amber color which characterizes its sirup when properly made. It is very rich in saccharine matter. When scientifically treated its products are destitute of that peculiar "sorghum" taste formerly complained of; the flavor is very similar to that of pure honey. The sirup readily granulates and yields sugar equal to the best ribbon cane of Louisiana.

The Early Amber cane on the department grounds did not grow quite so tall as the White Liberian. Its seed-heads were of moderate fullness and of very dark color.

Plate II shows the Chinese sorgo cane grown on the department grounds. Its height is about that of the Early Amber. Its seed-heads are fuller and more compact and somewhat resemble a head of sumac; hence the synonym "sumac cane." It is also known as "Chinese cane."

Plate III represents the White Liberian cane grown on the department grounds. This variety is rather taller than the Early Amber. The stalk curves at the top, leaving the head pendent; hence the synonym "Gooseneck." It is also styled a variety of the White Imphee. The seed-heads are shorter, more compact, and of lighter color than the Early Amber.

Plate IV shows the Honduras cane grown on the department grounds. It grows about one-half taller than either of the above varieties. Its seed-top is of reddish brown and spreading; hence its synonym "Sprangle Top." It is also called "Mastodon" and "Honey cane."

B.

MINNESOTA CANE GROWERS' CONVENTION.

A numerous and intelligent convention of the Early Amber cane growers and manufacturers of Minnesota was held at Minneapolis, January 22, 1880. The Commissioner had the pleasure of attending this convention and secured a phonographic report of its proceedings. As it embraced men of scientific attainments and of specific acquaintance with this new branch of productive industry, the discussions were remarkable for the vast number of facts and principles already accumulated in their experience. Of these it is proposed to furnish, here, an abstract showing the drift of opinion upon all the points of culture and manufacture.

SOIL.

There were some differences in the opinions expressed as to the availability of new land and, as usual in such cases, experiences varied. Some having expressed the fear that new land will impart a strong flavor to the cane-sirup, Mr. Wiley, who had large experience in both culture and manufacture, emphatically denied the fact. He said that while old land might produce a sirup of brighter color it was not at all better in taste. An advantage in using new timber land is found in the small amount of cultivation required. Costly culture on old land will not pay in opposition to cheap culture on new land. Mr. Wiley had paid as high as $15 per acre for hoeing. New land is comparatively free from foul seed and consequently less liable to a troublesome growth of weeds.

On the other hand Colonel Coleman, of the Saint Louis Rural World, and others contended that old land required less cultivation and produced better results. It was suggested that if it were necessary to clear old land of weeds or to fertilize it with barn-yard manure, a crop of corn should be grown upon it before planting the cane. The general opinion was in favor of a sandy upland soil, well drained, but not freshly manured.

In regard to manuring, facts were alleged to show that it spoiled the flavor of the sirup. A farmer had selected for his cane patch an old cow-yard. The stalks were tall and luxuriant, but the sirup would nearly "take off the skin of the mouth."

The great majority of opinion was in favor of the indefinite repetition of this crop on the same soil. The president of the convention mentioned the case of a neighbor who had cultivated the same ground most successfully for seven years without deterioration, his product ranging from 250 to 300 gallons of sirup per acre. Mr. Day and Mr. Dyer, of Hastings, corroborated this opinion from their own experience. The latter thought that his continued crops improved not only in quantity but also in quality.

The soil required for the cane is not necessarily very rich. A gentleman planted several knolls, too poor for wheat, in cane, and realized 200 gallons per acre of excellent sirup.

PREPARATION OF THE GROUND.

The general opinion was in favor of fall plowing. Mr. Farmer plows in August putting the plow to the beam. This caused all foul seed and especially pigeon grass to germinate in the fall and to be killed by winter freezing. Another advantage of fall plowing was that the crop was less liable to injury from droughts in the early season. Mr. Bozarth, of Iowa, after twenty-one years' experience in raising cane was decidedly in favor of fall plowing. In one case a portion of his cane patch, replowed in spring, yielded but half as much sirup as that which had been only fall plowed. On the other hand, Mr. E. A. Chapman, of Windham, had "demonstrated that a very large crop of cane can be raised the first year on the open prairie and at the first breakage." He had "broken 2 acres with the La Dow harrow, harrowing it completely, and it produced the best cane out of 5 acres." It was planted June 1, on black, loam soil. He believes that with the La Dow harrow "large crops can be raised on new breakings." "It did the work so well that several farmers got down on their knees to look at the soil; it looked so much like old soil." Those who practiced fall plowing were careful to stir the ground in the spring in order to destroy the weeds. Mr. Farmer, when the ground becomes sufficiently warm in the spring, goes over it with the Beaver Dam seeder and then with the drag and roller. This treatment effectually disposes of the grass, which point was generally considered of first importance.

TIME OF PLANTING.

There was some discussion on this point. The drift of opinion was expressed by the following resolution:

"*Resolved*, That the cane be planted as early as it is possible to work the ground properly, avoiding late frosts."

The ground should be well warmed before the seed is placed in it. In Minnesota the average seeding time is in the fore part of May, though several growers had been successful with plantings still earlier. The president of the convention thought that planting should not be quite so early on ground impregnated with grass seed. Mr. Wiley advised against planting till the season was warm enough to germinate the seed quickly. He had had later plantings which produced better than some earlier ones. A late spring frost might cut down early plantings and before they grew again the pigeon grass was apt to start up profusely. Mr. Wood had seen a field of cane some 8 or 10 inches higher than a neighboring field. He found that in the former case the seed had lain in the ground all winter and the latter had been planted early in spring. Experience and discretion were considered requisite to settle for each locality the exact time of planting as they are in all other cultures.

VARIETIES OF SORGHUM.

In a more southern latitude the cane grower may have considerable range of choice between different varieties, but for a locality so far north as Minnesota, the Early Amber, ripening within the productive season, is the only one that can be relied upon. The Commissioner of Agriculture, General Le Duc, by request, gave some very interesting facts in regard to the experiments with different sugar plants under the direction of the chemist of the department. The Early Amber cane was tested July 18, when the seed-head was just out, and showed 3.77 per cent. of glucose and 4.43 per cent. of sucrose. It was again tested August 16, 29 days afterwards, and found to contain but 1.54 per cent. of glucose, while the sucrose had risen to 14.67 per cent. Here was indicated a most important chemical change, in which not only the sucrose was enlarged, but over half of the grape sugar or glucose changed to cane sugar or sucrose. A third examination, September 16, 31 days afterwards, when the seed was ripe, hard, and dry, showed a still further enlargement of the sucrose to 15.95 per cent., and a still further absorption of the glucose, of which 0.65 per cent. was detected by analysis. Another examination, not long afterwards and just following a severe frost, showed little or no change, the sucrose had increased to 17 per cent. and the glucose to 1.00. These experimental results place the Early Amber almost on a par with the best Louisiana cane.

The departmental experiments included several other varieties of sorghum and other sugar plants. The Chinese cane was examined at the same times that the Early Amber, and gave the following results. When the seed-head was just out, there was 5.55 per cent. of glucose and but 1.85 per cent. of sucrose; when the seed was hard and dry, there were developed 1.85 per cent. of glucose and 13.90 of sucrose; after the frost, the glucose had enlarged to 1.85 and the sucrose had declined to 13.10. The White Liberian cane showed its maximum of sucrose 15.20 per cent., and its minimum of glucose 0.95 per cent., when its seeds were dry. The Honduras, before the seed-head was out, gave 5.13 per cent. of glucose and 1.20 per cent. of sucrose; when the seed was hardening, its glucose had fallen to 1.30 per cent. and its sucrose had risen to 15.10.

The Louisiana cane of 1879 gave a maximum of but 12.47 per cent. of sucrose; the growth of 1878 gave 16 per cent. The fact seems sufficiently evident that the sorghum as a sugar plant contains an amount of crystallizable sugar fully equal to the Louisiana cane.

SEED.

It was suggested that by steeping the seed in warm water for 24 to 48 hours it would become sprouted, and hence would grow more rapidly. But, on the other hand, it was urged that a dry season would kill the sprouted seed and the crop would be a failure. Nature porvides the most opportune moistening.

The weight of opinion was decidedly in favor of seed brought from the latitude of Saint Louis. Some cane-growers had sent their seed to Missouri and Kansas to have a crop grown and its seed returned. Among the decisive facts reported, Mr. Miller stated that his seed imported from Southern Indiana 11 years before had produced on its first sowing stalks from 12 to 15 feet high; but by planting the seeds of each crop its successor showed a declining height of cane until it grew but 7 or 8 feet high. Mr. Wylie had averaged, with seed brought from the South, 273 gallons per acre; the following year, using his own seed, he obtained but 223 gallons, a falling off of 50 gallons. The president of the convention had found, as a general thing, that the deterioration of seed was not very marked till the third year. The Southern seed did not excel so much in an earlier ripening of the crop as in its increased product, the excess, in some cases, amounting to one-third. The sentiment of the convention was expressed in the following resolution:

"*Resolved*, That Early Amber cane-seed, grown in the latitude of Saint Louis, is the best seed for Minnesota for two years."

The seed has a value of its own for consumption on the farm. It was pronounced excellent for feeding hogs, sheep, or poultry. The 5 or 6 tufts growing upon a hill of cane were estimated as equal in feeding value to three average ears of corn. A member of the convention pronounced it equal to oats. Another had found that the seed fed to sheep made the fleece look lively and polished.

PLANTING.

Plant just deep enough to secure moisture. Hence, earlier plantings should be shallower than late ones. There was some difference of opinion as to the arrangement of the hills. The president of the convention, Mr. Kenny, plants in rows 3½ feet each way and uses 2 pounds of seed per acre or 6 or 7 seed to the hill; at the second hoeing he thins them out. Mr. Day marks the rows 3 feet each way. Seed should be planted not down in the trough of the marking furrow where a heavy rain is apt to wash it away, but on the edge. Mr. Wiley plants from 15 to 18 inches one way and 3 feet the other way, the rows running north and south, thus doubling the number of hills planted by Mr. Day. A tract of 4 acres sown broadcast was reported as producing at the rate of 450 gallons per acre.

Mr. Miller practiced stepping upon the seed as they were placed in the ground. Several planters present sanctioned this practice, urging that the close pressure of the soil around the seed enables it to germinate more rapidly. It was objected that stepping the seed caused the ground to bake, but it was replied that this was the case only with wet clay ground.

CULTIVATION OF THE CROP.

The leading point presented in the culture of cane is keeping it clear of weeds. This requires prompt action with the hoe, drag, and cultivator. A grain farmer suggested the use of Thomas's harrow, of 90 steel teeth, but the general sentiment was that the cane-plants were too tender for any such treatment. It should be thoroughly hoed until large enough to cultivate with the plow or cultivator.

TIME TO CUT THE CANE.

Mr. Whiting had found the best results from early cuttings, but admitted that in the later cuttings it was the extreme hot weather that had changed the sucrose to glucose. The president thought the proper time was when the seed is in the stiff dough, or from August 28 to September 1. It seems to improve for a few days, but afterwards it begins to decline in saccharine matter. The earlier the cutting after the seed has reached the dough stage the larger the product and the brighter and cleaner the sirup. The question of suckering was considerably debated, and facts both *pro* and *con* were alleged, but the convention expressed no collective opinion.

HARVESTING.

The question of stripping the leaves elicited considerable discussion. On the one hand it was urged that if the leaves were put through the mill with the stalk they would absorb a large portion of the juice. It was replied that this would not be the case with mills of sufficient power. Force enough should be applied to express the whole of the juice.

It was complained that cane-growers lost a great deal by purchasing cheap and poor machinery. One gentleman estimated the cost of stripping the leaves before cutting at $15 per acre. Some advocates of stripping were disposed to admit that it would not pay unless labor were plenty and cheap. The Commissioner of Agriculture stated that the department experiments showed little or no difference between stripped and unstripped cane, although the department mill was an indifferent one. Several urged that if the leaves were dry they would not in any way affect the quality of the sirup. The convention did not express any general opinion upon this point. It was considered of first importance that the tops be completely removed, as a single top sent through the mill would spoil a large amount of sirup.

The cane should be cut, some say, 6 or 8 inches from the ground, and others, at the first joint. The top should also be cut off from 18 inches to 2 feet; there is no sweetness in either the tops or the roots. Some planters laid the cane in windrows, and others were opposed to the practice as exposing the leaves if not the stalks to mildew. The storing of cane after cutting started discussion. Some insisted that it should be immediately placed under cover to avoid the evaporation of the sun's rays. Others piled in ridges 4 feet high, and covered the mass with marsh hay. To this it was objected that the lack of ventilation would spoil the cane. To obviate this difficulty some planters were in the habit of laying poles along the piles every 2 feet, in order to admit fresh air. Some would pile it as cane is sometimes piled in the field, crossing the hills in such a way as to secure ventilation and to shed the rain. Cane that had been kept in these different ways for several weeks were reported as having produced large and fine sirup products. One planter produced juice that ranged from 7 to 10, from cane that had been stripped and covered with leaves, while other cane of the same lot, that had been ground with leaves on, ranged as high as 12. Dr. Goesman, of Massachusetts, was quoted as saying that there was a gain of 3 per cent. by being allowed to lie with the leaves on. One planter had found such cane to test 11, while stripped cane tested only 10. The higher per cent., however, was by many attributed to the evaporation of the watery part of the sirup, leaving the saccharine matter in larger proportion to the residue. Others had not found the juice to be any sweeter after evaporation.

TRANSPORT OF CANE TO THE MILL.

Mr. Wiley thought it would pay every farmer to have his own mill. The price of the sirup in the market ranged from 35 to 50 cents per gallon. The mill owner will charge from 15 to 25 cents per gallon; if to this be added a charge, say of 10 cents per gallon, for hauling to a distant mill, it is easily seen that the grower gets but a small proportion for his labor. It cost the president $19.14 to haul the cane of 12 acres—part of it near the mill, and the remainder about a quarter of a mile away. It is better for the farmer to have the profit of manufacturing the cane as well as of raising it. In moving the cane from the field there was a strong expression in favor of bundling it. Some would decapitate it with a broad-ax, after binding. Some used a common dump-cart with an elongated box. The points kept in view, both in the transportation and in the storing of the cane, were protection from the weather, and such ventilation through the mass as would prevent mildew.

GRINDING.

The first step in the manufacture of sugar and sirup is the grinding or crushing of the cane to express the juice. Mr. Miller saw men at work with a very indifferent apparatus, which extracted but a small portion of the juice. On remonstrating with them he was told that if you extracted too much of the juice it soured the whole. This ignorant prejudice assumes what chemical analysis and intelligent experience has exploded—that only a portion of the juice is fit for evaporation. The almost universal expression of the convention was in favor of extracting the last possible portion of the juice. For this purpose the most powerful mills were considered as essential to the working of the crop. The president, Mr. Kenny, has a mill weighing 4,000 pounds, with rollers 16 inches long and 16 inches in diameter; with a 24-horse power engine it expresses 4,000 gallons of juice per day, getting from 65 to 70 per cent. of the juice in the stalk.

Mr. Keating had a small mill, expressing about 75 gallons per day, that worked very well, cutting every stalk at the joints and feeding 8 to 15 stalks at a time. Mr. Whitney says that small mills, like the Victor, if not too much crowded, will crush the cane perfectly dry. Clark and Utter's mill, manufactured at Dodge Center, with back gearing, was reported as a very efficient mechanism; its cost was $100. The general sentiment was that the milling machinery should be sufficiently powerful to obtain the largest practicable per cent. of juice in the stalk. It was estimated that Minnesota farmers had lost thousands upon thousands of dollars through the use of poor machinery. Mr. Whiting gave a humorous account of his efforts to construct a wooden mill, which amounted to nothing.

In regard to the method of feeding the mill, it was urged that the cane should be inserted evenly, and with the butt ends foremost. The supply should be regular and up to the normal capacity of the rollers. It is not desirable that it be full at one time and half full at another. There is a considerable art in properly feeding a mill. An incompetent feeder will clog it up, from time to time, by an irregular supply.

TREATMENT OF THE JUICE.

After a thorough extraction of the available juice in the cane, the next step is its evaporation and defecation. Heat is the great agent in the clarification of the juice. Hence Mr. Earle claimed that the most important element in the whole process of manufacture is a good furnace. He would select a hillside fronting the direction of the prevailing winds in September, so as to secure as great draught as possible; place the furnace on a level lower than the mill, with a fall of at least 10 feet. With a furnace in this position, properly constructed, he has had but little difficulty in throwing a flame 16 feet higher than any ordinary height of stack, using the bagasse as fuel. It can be done also with light wood, but not with heavy wood. The furnace must have a ventilating flue. Mr. Wylie had scared his horses at night by the bright flames coming out of his stack. The president, Mr. Kenny, suggested it was not just the thing to send the heat in flames 15 feet above the stack; all that can be utilized is that which operates under the evaporating pan. Under the instructions of Mr. Swartz he had reconstructed his arch so that instead of a great blaze at the top of the stack there was an intense heat under the pan.

Mr. Earle had arranged his pans on different levels so that the back pan was 7 inches higher than the other. Mr. Dickenson followed the directions of an expert in the construction of his furnace, but could not get the back part of the pan to boil till he had torn out the furnace and reconstructed it in accordance with his own ideas. He raised his stack from 15 feet to 28 feet and would prefer at least 30 feet. To control the draught he put in dampers. He adopted other contrivances for concentrating the heat under the pan. As cord-wood was too coarse, he hired a man to split it fine. Oak and maple were unfit, but basswood, poplar, and other light, free-burning kinds will just meet the demands. The more rapid and intense the heat under the pan, the more complete the evaporation and defecation of the juice. Mr. Miller, who had formerly shared Mr. Dickenson's prejudice in favor of light wood, saw a counter-demonstration in Mr. Swartz's factory. There heavy red oak and jack-oak sticks were made to produce an intense heat by mingling them with coal. Mr. Swartz's arch was 2 feet deep and 2½ feet wide. It is best not to cramp the arch, but make it wide enough for the embers to spread and present a broader heating surface.

There were differences of opinion in regard to smoke-stacks. The prevailing tendency to make the pipes too small was noted by several speakers. One member stated as a scientific principle that the cubic contents of the stack or chimney should be at least two-thirds of that between the grates and the fire. Mr. Miller thought Mr. Swartz's chimney a perfect pattern. It was 35 feet high, and from 2 to 3 feet in diameter. No flame came above the stack at night. The width of his own fire-place is about 30 inches, with which he is able to boil as fast as desirable with dry basswood and poplar.

Mr. Swartz does not break the scales off his pan, but lets them remain till they become loose of themselves; then they would be removed in the daily cleansing of the pans. He finds that the Liberian cane deposits a scale entirely different from the Early Amber. The sirup of the former does not turn nearly as early as that of the latter. Mr. Wylie gets rid of them by burning a forkful of straw under the pan when it is perfectly dry and clean. Then under the quick flame the scales will blister and fall off.

Mr. Wylie for five years had used the "Cook" pans. A neighbor, Mr. Stubbs, had made a new one, that is patentable, costing but $35, while Cook's cost $90. It is from 14 to 16 feet long, and has two partitions in it. It easily makes 100 gallons a day, a result requiring hard labor with Cook's pans. One man, with two of Stubbs's pans, can easily make 200 gallons a day, and read the newspapers besides. This opinion, however, was far from unanimous. A member had used Stubbs's pan for two years, but was dissatisfied with its results. It employs the principle used in the Faribault refinery in the collection of the skimmings. Mr. Wylie described the "Stubbs" pan with the aid of a diagram; sides 14 inches high, 36 inches broad on top, 16 feet long. It is arranged with a center foundation so that it cannot burn; the heat is cut off with a damper. In producing 2,725 gallons of sirup, Mr Wylie had used 4½ cords of wood, at $1.25 per cord. The center arch is within 5 feet of the front of the pan. It is set level. Five years ago the Cook pan only was used in Medina, Minn., now not one is in use there, while twenty Stubbs pans are used. It is better than the Blymyre pan because it skims itself, and there is no clinging of the skim to the sides.

Mr. Miller had invented an attachment to the Cook pan, which overcomes all the difficulties heretofore complained of. Cook's pan, with this attachment, runs the juice in and the sirup out without change. It does not discolor the sirup by reboiling. Hence the sirups made in Cook's pans are clearer, and freer from muddiness, than other sirups. Mr. Wylie denied that sirups boiled in the Stubbs pan were at all muddy, and showed a very fair specimen. The merits of different pans were presented at some length by different speakers.

C.

ILLUSTRATIONS OF SUGAR MACHINERY.

The following illustrations of the mechanical processes of sugar-making in different parts of the world are not intended to advertise the business of the manufacturers who have so kindly furnished cuts of their machinery for this report, but to present to farmers desiring to engage in sugar-production type specimens of approved methods of working up the cane. There are other manufacturers whose models do not appear in this report, who, doubtless, are able to furnish machinery at reasonable prices. The purpose of these illustrations is to present to sugar-growers some of the facilities which the market affords for their enterprise and to put them upon inquiry as to where they can obtain the best machinery and at the lowest prices.

Plate V shows the Victor cane mill, an apparatus in very common use. It is constructed with vertical rollers on a plan suited to horse-power, or with horizontal rollers for water or steam power. The horizontal mills are fitted with extra gearing, are necessarily heavier and require greater motive power to accomplish the same result. Plate V shows the vertical mill, of which seven sizes are on the market; the smallest is a 1-horse power mill, running 40 gallons of juice per hour, and weighing 395 pounds, at a cost of $48; the largest is a 4-horse power machine, 1,900 pounds weight, running 170 gallons per hour, and costing $230.

Plate VI shows the vertical Victor mill, with the horse-power operating in a lower story. The advantages claimed for this arrangement are, 1, the mill is more steady;

2, horses and cane do not interfere with each other; 3, the bagasse is more easily removed; 4, the juice flows down into the evaporator. For five different sizes the prices are $90, $105, $140, $155, $240.

Plate VII represents a horizontal Victor mill adapted to steam or water power, of which three sizes are in the market, viz, No. 1, weighing 2,200 pounds, and valued at $250; No. 2, 3,500 pounds, $350; No. 3, 4,000 pounds, $450.

Plate VIII, Fig. 1, represents a portable "Cook" evaporator, of which three sizes are for sale. These pans are 44 inches wide and from 6 to 9 feet in length, ranging from 40 to 90 gallons per day. When the pans are of galvanized iron, the prices are, respectively, $65, $75, and $85. With copper pans the prices are from $55 to $70 higher. Each contains a portable furnace. The whole can be lifted into a wagon by two men and transported from field to field with a light Victor mill, and thus save the transportation of the cane.

Plate VIII, Fig. 2, represents a "Cook" stationary evaporator, of which there are seven sizes, adapted to corresponding sizes of the Victor mills. They are bedded upon brick or stone arches, and are 44 inches wide, ranging in length from 6 to 15 feet. Their capacity is from 40 to 180 gallons per day, and their price from $30 to $90 for galvanized-iron pans, and from $80 to $210 for copper pans. Furnace fronts and doors cost from $5.50 to $8; grates, from $4 to $8.

Plate IX represents still larger sizes of these pans.

Plate X represents a complete sugar factory, the size and cost of which must necessarily vary with the number of acres of sugar-cane to be worked up. A is the juice-tank; the juice, after running from the crushing-mill into a tank on a lower level, is pumped up to the juice-tank in the upper portion of the building. B is the defecator for the elimination of crude impurities. C C are settling tanks; D, supply tank from which the evaporator is fed; E, a Cook evaporator; F, supply-tank for the strike-pan; G, strike-pan, in which the semi-sirup is reduced to the proper consistency for sugar; H H, receptacles for scum; I, truck for carrying the sirup to the sugar room; J, the sugar-room, with cooling-boxes, barrels, &c.; here an even temperature is kept up to assist granulation; here, also, the sugar is drained and stored.

Plate XI represents a steam plant, or steam train, consisting of a duplex mill for grinding the cane. It has two sets of housing, and each set two rollers. Each stand of housing and rollers is placed 6 or 8 feet from centers, and the intermediate space occupied by an endless carrying-frame traveling in the same direction as the rotation of the wheels, and at the same speed. The cane is fed to one set of rolls, called the roughing-rolls, which slit and crush it. It is then received by the carrying-frame of wooden slats and carried to the other set of rolls. It is moistened, on its way, by a spray of water thrown by a steam jet. This saturates and fluxes the sucrose, not yet extracted, which is then obtained. This residuum, though diluted with water, is the richest of the whole. This mill, when properly fed, will grind from 5 to 6 tons of cane in twenty-four hours.

Plate XII is a vertical view of the last.

Plate XIII is a defecating tank 8 feet long, 5 feet wide, and 2 feet deep. Over the bottom is spread a manifold of steam pipe, and contains a strainer through which the juice, perfectly clear, can be drawn off. The tank may be cleansed with pure water for a fresh filling. Each tank-full can be handled in thirty minutes. Two of these tanks are connected with the mill, and are ample for defecating 600 gallons per hour.

Plate XIV represents an evaporator 6 feet in diameter and 4 feet deep. Each is furnished with coils of steam-pipe 125 feet long, and a diaphragm directing the currents of evolution over the steam-coils up the outside and down the middle axis. In the center of the pan is an adjustable, funnel-shaped skimmer, which may be raised or lowered, so as to be on a level with the surface of the boiling juice. It catches all the scum gathered by the currents and delivers it through a pipe penetrating the bottom, outside of the evaporator. Two evaporators will reduce 600 gallons of defecated juice to one-half the volume in an hour and a half.

Plate XV represents the concentrator, which differs from the evaporator by having a closed top and a water-jet condenser, producing a vacuum. In this vacuum 600 gallons of evaporated juice are reduced to 200, or only one-sixth the volume that entered the evaporator. This reduced liquid is called semi-sirup, and can be stored in tanks or shipped in barrels to a refinery, or reduced to a dense sirup in a vacuum-pan constructed very much on the same plan as the concentrator.

A complete sugar-mill, embracing the above apparatus, with engines, boilers, centrifugal dryer, tubs, tanks, and all other necessary appliances for making sirup and sugar, will cost about $10,000.

Plate XVI represents a very heavy crushing mill. The smallest size of this series of mills has rollers 12 inches in diameter and 20 inches long, expressing from good ripe cane about 150 gallons of juice per hour. Larger sizes do a proportionately larger share of work.

Plate XVII is an "exhaust steam clarifier." Heat is applied to the juice; the albumen is coagulated and the acid neutralized by milk of lime, which also renders insoluble sundry soluble impurities and precipitates them. But as an excess of lime attacks the sugar in the juice it is of special importance that its quantity be regulated. In this clarifier this is done by means of a vessel graduated by inches, each inch corresponding to 4½ cubic inches of milk of lime. The total quantity of the lime ranges from 0.01 to 0.03 per cent. of the total weight of the juice. When the proper temperature has been acquired, the scum rises to the top and begins to break and show bulbs. The proper point of defecation is then considered to have been reached, and the clarified sirup is drawn off by means of a double cock in the bottom of the defecator. The scum and precipitates are discharged through another channel.

Plate XVIII is a "direct steam evaporator," which receives the clarified juice from the steam clarifier shown in Plate XVII. The juice is boiled by means of a coiled steam pipe. The resulting scum boils over into a trough around the upper edge of the evaporator and is itself subjected to defecation afterwards.

Plate XIX represents a "steam train" of three clarifiers and one evaporator, represented in Plates XVII and XVIII. This steam train requires but few men to work it and is very cleanly in its action. It dispenses with pumps and ladles. The sirup is fully prepared for the vacuum-pan.

Plate XX represents a vacuum-pan. This pan can be placed upon framing or walls built up in the house, but it is considered preferable to support it upon iron columns as in the plate and independent of the building. The elevation should be sufficient to admit of discharging the "strike" into the "centrifugal mixer." The plate shows a vacuum-pan arranged to work on the "wet" system; that is, in combination with a water-pump. The sirup is boiled at a very low temperature, producing a larger quantity and a better quality of crystallized sugar, yet the boiling is so rapid that the sugar does not get time to become inverted. Heat is applied to the sirup by means of a coil of copper pipe filled with steam, which, on being condensed, is conducted back to the boiler.

Plate XXI represents a combination styled "Multiple effect." It embraces a direct fire evaporator for the first juice, working under a vacuum in connection with a strike pan with the combined water and vacuum pump, also the mixer and centrifugal machine. This machinery is especially designed for making sugar from sorghum and cornstalks. The process consists in boiling the juice in a tubular or cylindrical boiler very similar to a steam-boiler, the fuel being only the bagasse. The vapor is conducted by pipes to the valves in the vacuum-pan and admitted to the copper coil which serves as a surface condenser. A vacuum-pump draws off the condensed liquid and the vapors. As the liquid thickens it is passed to the strike-pan where, by means of a higher vacuum, the boiling is perfected into crystal. It is then discharged into the mixer, where it is gently stirred to prevent "settling." It is then drawn through valves in the bottom of the mixer into the centrifugal, where the molasses is eliminated and the granulated sugar fitted for packing. The molasses is discharged into a tank and reboiled, after which it is passed into cans and allowed to granulate; finally, the molasses is eliminated, as in the first run. The only use of a steam-boiler in this process is to drive the cane-mill and the centrifugal, which will require a small engine. This feature is claimed as a special advantage in cutting down the expense of the process. As there will be no very heavy pressure there is no danger of explosion, and consequently the boiler may be made less expensive. This method of reducing *in vacuo* prevents caramelization, as the air is kept off and only a low heat employed. The prices of this apparatus vary with the results to be obtained.

Plate XXII represents a form of centrifugal machine called the "German style." It runs in elastic bearings and does not require to be set in masonry. Its manufacturers claim that it will purge from 1,000 to 1,500 pounds of sugar per hour. Price, $400, with $10 extra for boxing.

Plate XXIII represents a "Hanging centrifugal machine," especially adapted to certain classes of gummy sugars. It requires no specific skill in the operator. Price, without frames, $775; with frames, $955, or $900 each for two machines; boxing, $10 for each machine. It is larger than the German machine described in Plate XXII, and discharges the sugar through the bottom. It will purge from 2,000 to 4,000 pounds of sugar per hour.

Plate XXIV represents the latest improved centrifugal driven from below. It will purge from 2,500 to 5,000 pounds of sugar per hour. Price, with frames, $1,000; two machines, $950 each; a machine without frames, $850. The sugar is discharged through the bottom.

Plate XXV, Fig. 1, is a cheap home-made evaporator, which can be put together by any ingenious mechanic. It is constructed by putting wooden sides and ends upon a galvanized iron or copper bottom.

Plate XXV, Fig. 2, is a pan for cooling sirup sent by a correspondent. Its method is sufficiently clear from the diagram.

Plate XXVI represents a newly-invented "evaporator." It is available either for concentrating cane-juice to the density of sirup to be finished in the vacuum-pan or, if the vacuum pan is not used, directly up to the point of granulation of sugar. Th defecated juice is brought through a canal shown on the left of the picture and deposited *continuously* in the first table of the evaporator. When it has acquired a depth of two inches steam is introduced into the pipes and ebullition immediately commences and the impurities begin to rise. The latter flow outward to the sides and are held there by a constant outward current. They may be removed without any waste of the juice. The discharge of water resulting from condensation is regulated by a valve. The gate is then opened and the juice is passed to the second table where it is subjected to the same process, and then to the third table. By the time it is ready to pass from the third table it is reduced to a density varying from 18° to 32° B. It then passes to the strike-pan on the fourth level where it is brought up to the sugar point. It is then drawn, either in a continuous stream or by "strikes," into molds or hogsheads. Not less than 15 hogsheads or 30 moulds should be ready for the sirup. These should receive, each in its turn, about 2 inches depth of the liquid, and when the last has received its quota begin again at the head of the series. This method of filling gives the sugar time to crystallize and cool; it dispenses with tanks and with a second handling. It is claimed in behalf of this apparatus that its elimination of impurities at the commencement of the operation, the limited time in which the sugar is subjected to the heat, and the low temperature used, cause only a minimum of inversion of cane sugar into grape sugar. An apparatus producing a cubic yard of sugar per hour is 29 feet long by 7 feet wide. It will require about 4,000 bricks to construct the walls. These trains are of all sizes desirable, with capacities ranging from 100 gallons per day to 1,500 gallons per hour. Prices from $50 for two small pans to $3,000 for large trains complete.

Plate XXVII represents the Stubbs Evaporator. The first cut shows the pan with two compartments. The first occupies three-fourths of the pan; the second compartment the remaining fourth. The juice enters the first compartment near the smoke-stack in a regular stream, passing around the circle over the fire-box to cross-partitions, where it thickens to a semi-sirup. Being over the hottest part of the furnace, it raises to a light foam, which breaks to the lowest point where the cool juice enters, not only keeping back the green scum, but carrying all the scum off of thirty feet surface, where it is scraped off without loss of sweet. The semi-sirup is turned into the second compartment at intervals to be finished under full control of heat governed by dampers. When done, to be run off with scraper, letting semi-sirup follow. Boil rapidly with two inches juice in order to cleanse well.

The second engraving represents the furnace. Should be built of brick, with eight-inch wall fourteen inches above fire-grate; the balance seven inches. A sectional arch with one damper in center, hinged at the back end to swing to back wall; also damper across the mouth of left flue. The smoke-stack stands back as the cut indicates. The smoke-stack should be 16 feet high, 14 inches diameter.

Price of evaporators.

Galvanized iron:	
No. 20, 16 feet long by 40 inches wide	$50
No. 20, 12 feet long by 36 inches wide	40
Charcoal iron:	
No. 20, 16 feet long by 40 inches wide	40
No. 20, 12 feet long by 36 inches wide	35

Plate XXVIII represents the mill, evaporators, &c., on the grounds of the Department of Agriculture at Washington, where the experiments of the last two years were performed. A description will be found in the chemist's report.

SUGAR-MAKING AMONG THE HINDOOS.

In 1822 the English East India Company published an exhaustive report upon "the culture and manufacture of sugar in British India." In the appendix is printed an extract from "Dr. Buchanan's journey from Madras, through Mysore, Canara, and Malabar, in 1800." The following illustrations present the processes in use among Hindoo sugar producers at the beginning of the present century.

Plate XXIX represents a sugar-mill consisting of mortar, beam, lever, pestle, and regulator. The mortar is constructed of a tree trunk, and is about 10 feet long and 14 inches in diameter, and is sunk 8 feet in the ground, leaving but 2 feet above the surface. The upper end is hollowed into an inverted conical depression in which the cane is crushed by a pestle, the juice being delivered by a tube running from the lower part of the mortar. Around its edge is a groove which receives what juice may overflow and conducts it by a pipe into the main receptacle. The beam is a portion of a tree 16 feet long and 6 inches thick, cut below the forks. The angle is enlarged and rounded, so as to embrace the mouth of the mortar around which it revolves, supported by a flange. The forks are then drawn together. On this beam are seated the mill-feeder and the ox-driver. The lever holds the pestle in its place, being held at one end by an upright piece of timber, called the regulator, to which it is pinned, and at the other end by ropes. The revolution of the pestle upon the small cut cane expresses the juice; the bagasse is removed by hand. The shape of the lever and the cavity in which it receives the upper end of the pestle causes the latter to revolve on an oblique axis; the lower end of the pestle is conformed to the conical depression in the mortar so that the cane may be subjected to the closest pressure. It is scarcely necessary to repeat the observation of Dr. Buchanan, that the machine is badly contrived. The sugar-makers of the village have each his turn at the mill, which is run night and day till all the crops have been worked up. The mill grinds about 56 pots of juice, or 218 gallons, in 24 hours. The oxen are driven at a rapid gait, and require to be changed several times during the day and night.

Plates XXX and XXXI represent modified forms of the Indian sugar-mill. The principle of pressure is the same in all, being the revolution of a pestle on an oblique axis in the conical depression of the mortar. The modifications are shown with sufficient clearness in the plates.

Plate XXXII represents a set of sugar machinery in use at Burdwan, near Calcutta, in 1792, as described in the minutes of the Indian Board of Trade of that year. The mill consists of two small wooden grooved cylinders working in a horizontal plane and propelled by two men turning spokes connected with each cylinder. This apparatus seems to be very inefficient compared with what was employed on the West India sugar plantations, but it is cheap, and worked by cheap labor. Heavy iron cylinders brought from England at great expense were unable to compete with the native machinery on account of the greater cost of working. In the left rear of the sugar-mill is seen a furnace with earthen pots for the boiling of the juice. The furnace is shielded from the weather by a shed open at the sides. The juice is dipped from one pot to another till, in the judgment of the boiler, it is sufficiently condensed. In this state it is called *goor*, a word which has no equivalent in English. The English in Hindoostan confound goor, sirup, or molasses under the general name of jaggary.

The goor goes to the *myrah* or boiler, who purifies it by different processes. The general method is that of boiling. Sometimes the molasses is first drawn from the grain and the goor is then boiled with milk, or with milk and water. In other cases the goor is only boiled and purified. Milk, lime, and lye from plantain ashes are used to cleanse and granulate the sugar. When boiled sufficiently it is put into earthen pots and two sorts of aquatic weeds of a supposed alkaline quality are used to drain off the sirup as clay is by European refiners. Clay is also used in some parts of India. Sugar thus prepared is called *cheenee*. Variations from the above methods are noted as prevalent in different parts of the country.

STEWART'S PROCESS.

Plate XXXIII represents the necessary addition to the ordinary sorghum machinery if the process of Mr. F. L. Stewart, of Murraysville, Pa., be used in making sugar. The plate illustrates the mode of using his powder B. H is the heating-tank, D the defecating-tank, from which clear juice is passed from the heater H. A stout, well-hooped half-barrel or ten-gallon cask, C, stands alongside the defecating tank, the head of which is pierced with two holes, at opposite sides, one five-eighths inch and the other one and a quarter inches in diameter. F is a lacquered funnel, with a gum ring fitting around its neck; *r* a plug, with gum fittings to insert tightly in the throat P, and a piece of rubber tubing, R.

EARLY AMBER CANE.

[Grown upon the Department grounds during the season of 1879.

Plate II.

CHINESE SORGO CANE.

Synonym: SUMAC CANE, CHINESE CANE.

[Grown upon the Department grounds during the season of 1879.]

Plate III.

Marx del.

WHITE LIBERIAN CANE.

Synonym: GOOSE NECK, White Imphee.

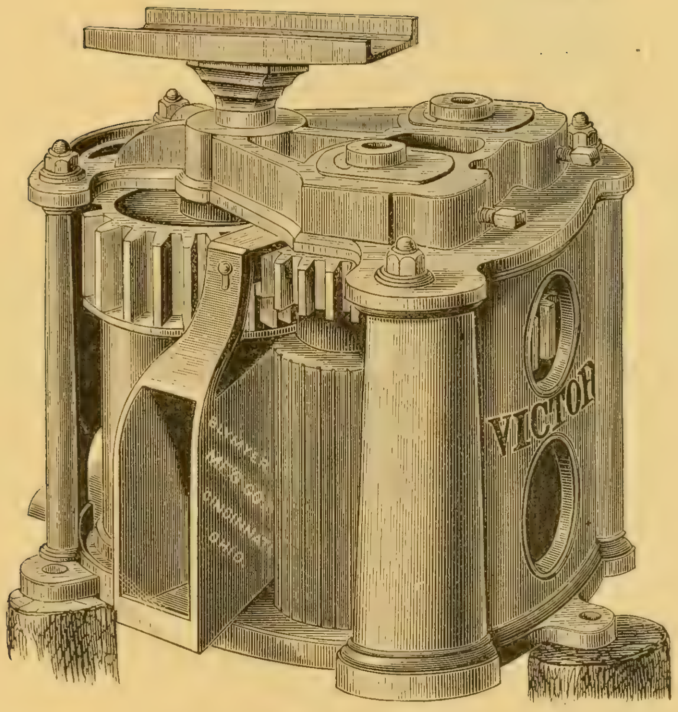
[Grown on the Department grounds during the season of 1879.]

HONDURAS CANE.

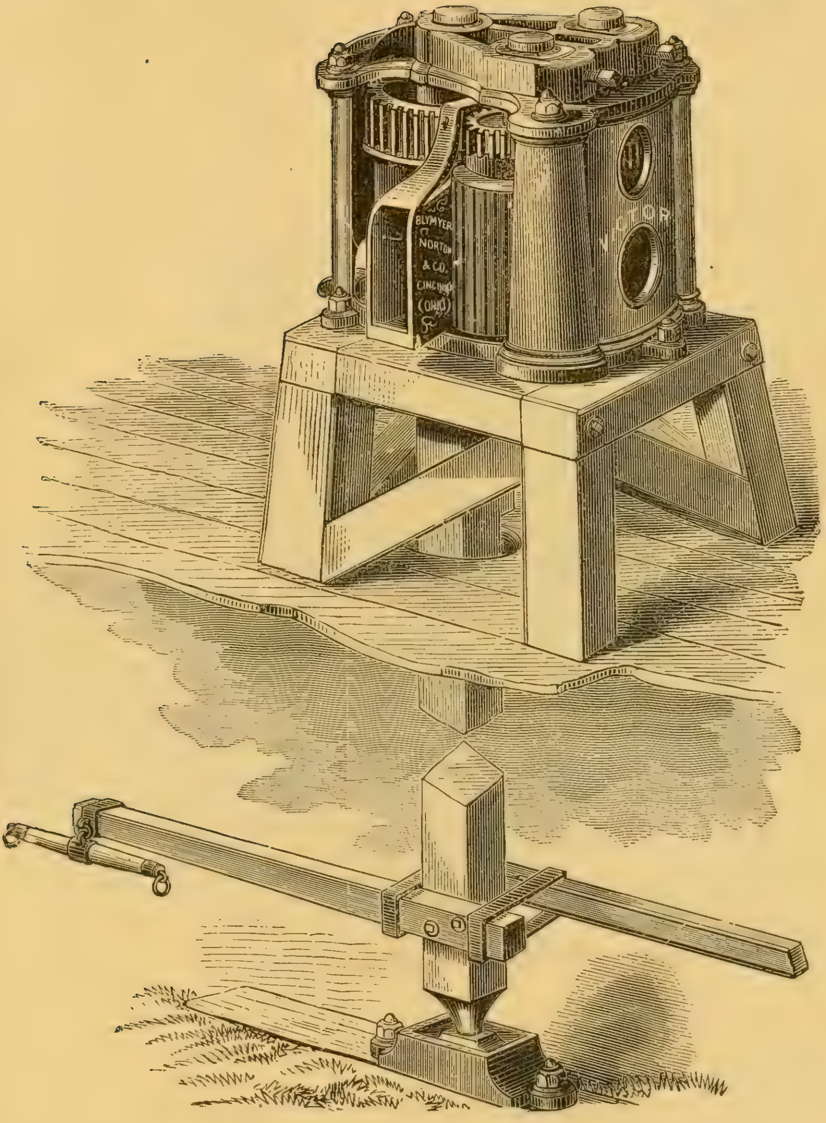
Synonyms: MASTODON, SPRANGLE-TOP, HONEY CANE.

[Grown on the Department grounds during the season of 1879.]

Plate V



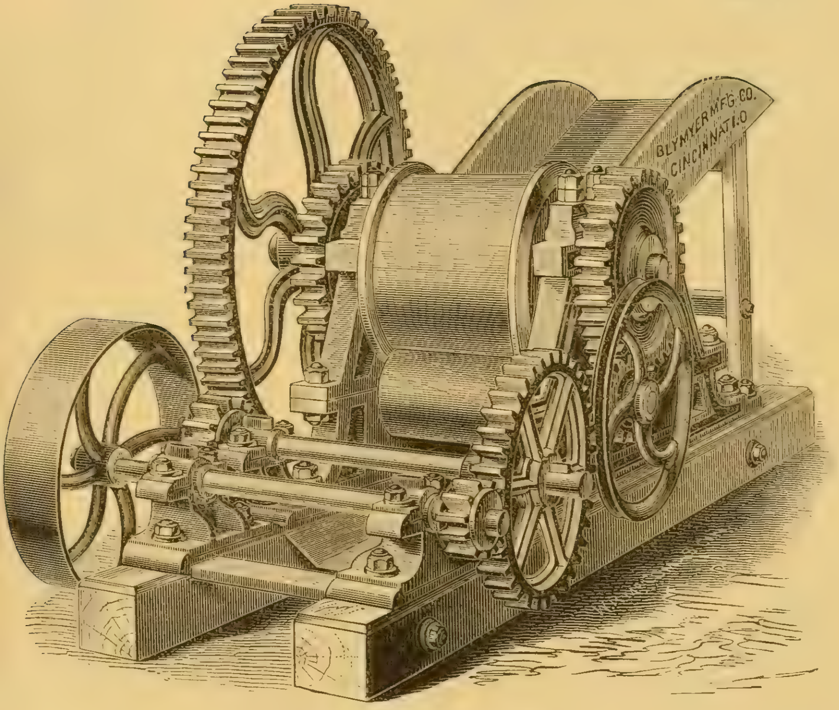
VICTOR CANE MILL (VERTICAL).



VERTICAL VICTOR MILL.

[With horse-power below.]

Plate VII



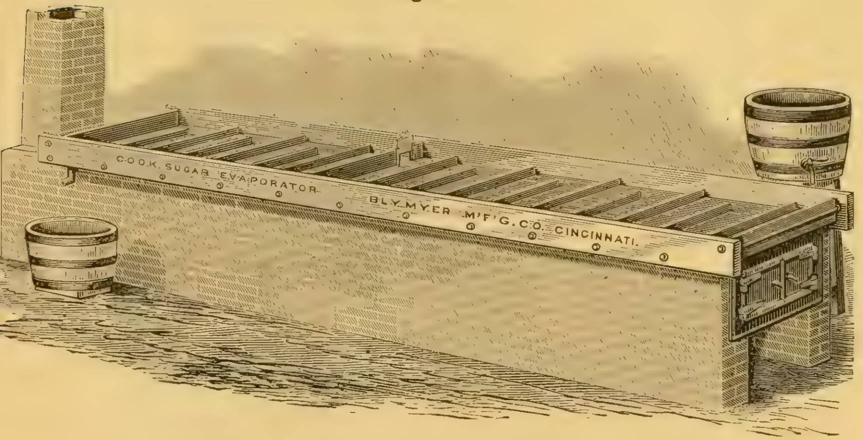
HORIZONTAL VICTOR MILL.

Plate VIII.

Fig. 1.

PORTABLE COOK EVAPORATOR.

Fig. 2.

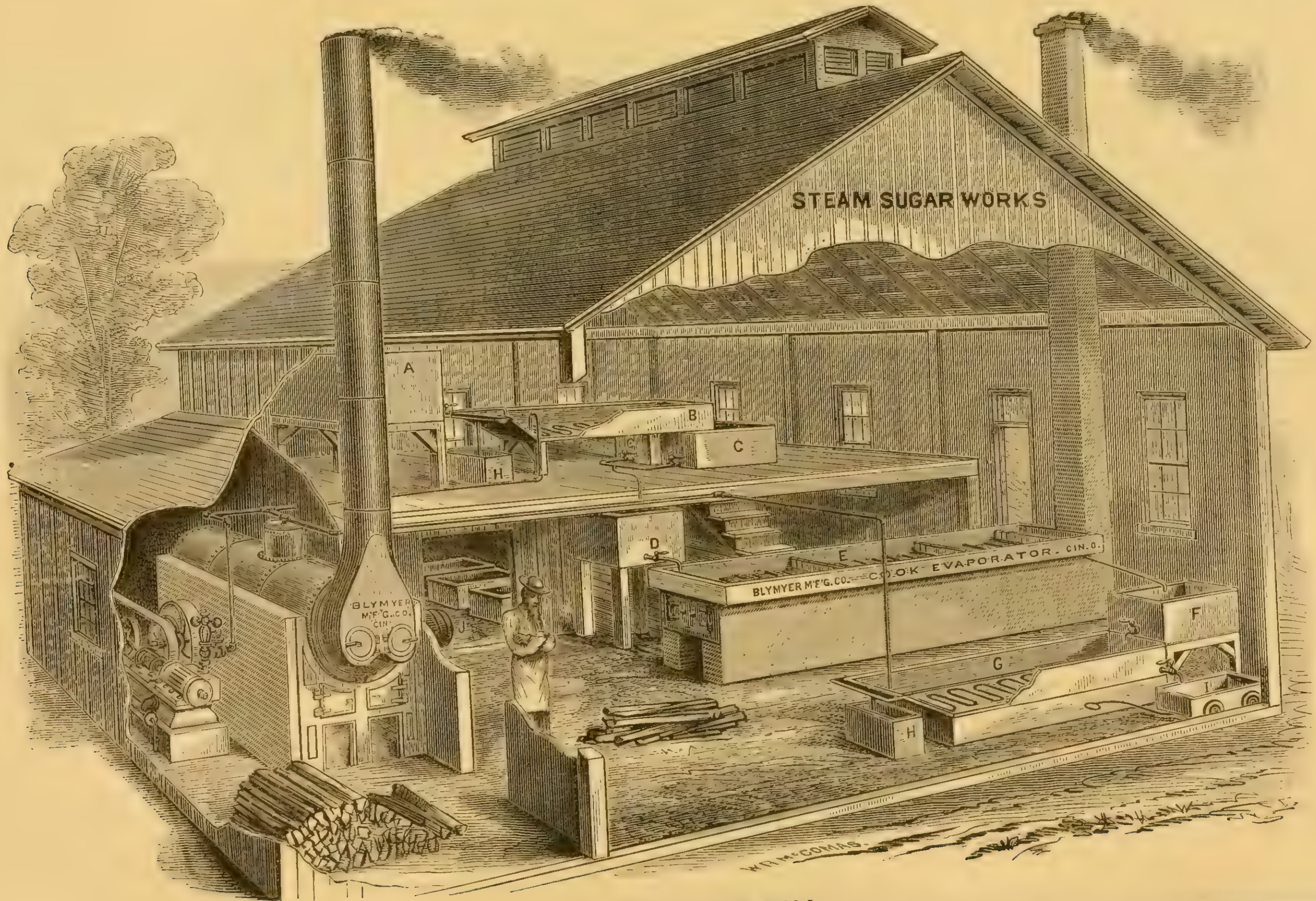


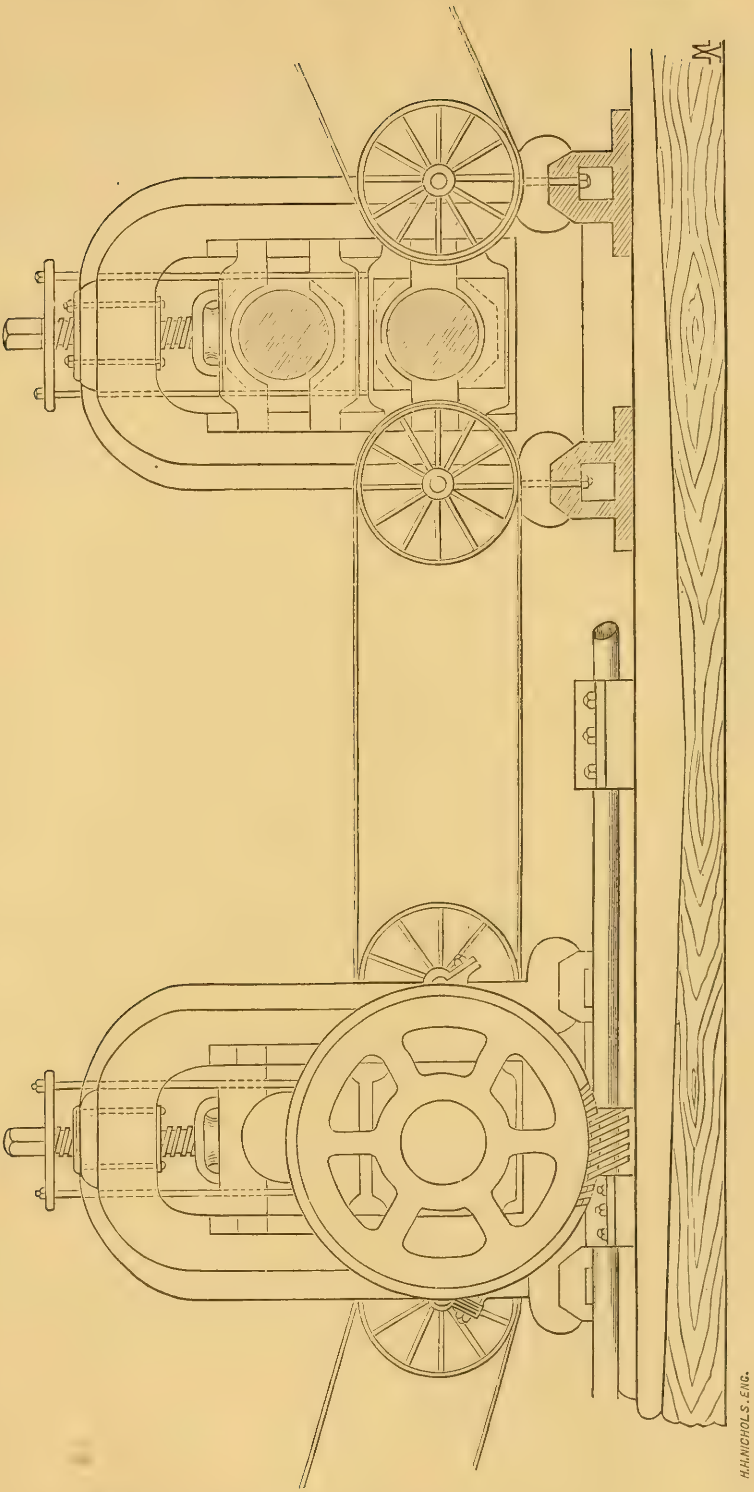
COOK STATIONARY EVAPORATOR.

Plate IX

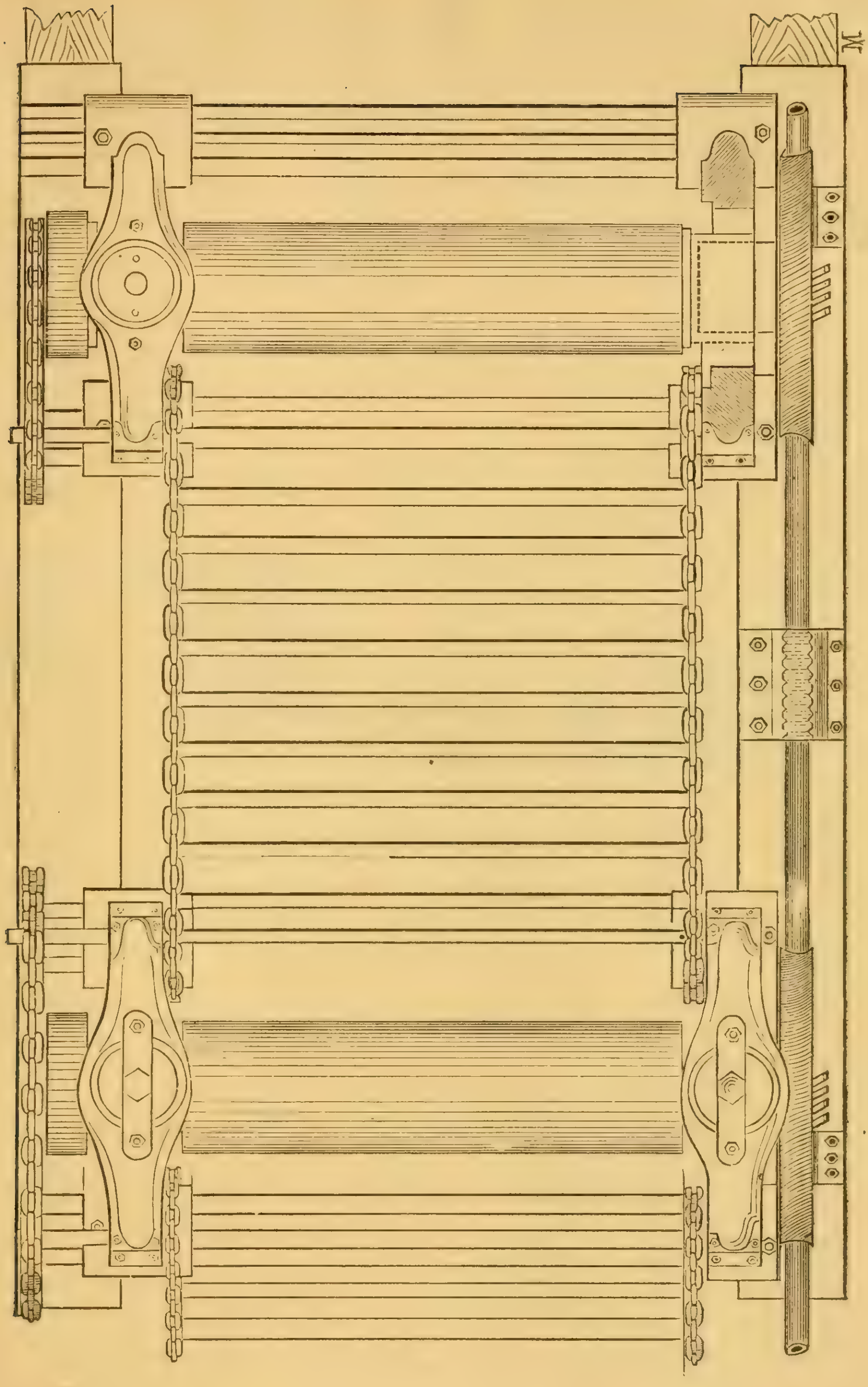
LARGE STATIONARY COOK EVAPORATOR.

Plate X.


STEAM SUGAR WORKS
A
B
C
D
E
F
G
H
H
H
J
BLYMYER MF'G. CO. CIN.
BLYMYER MF'G. CO. COOK EVAPORATOR. CIN. O.
WM. McCOMAS.



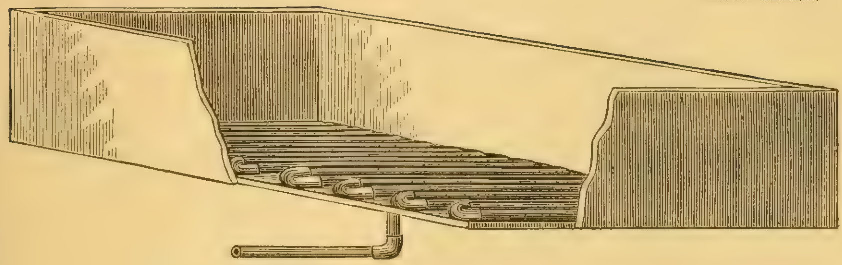
McDOWELL'S STEAM PLANT OR TRAIN.



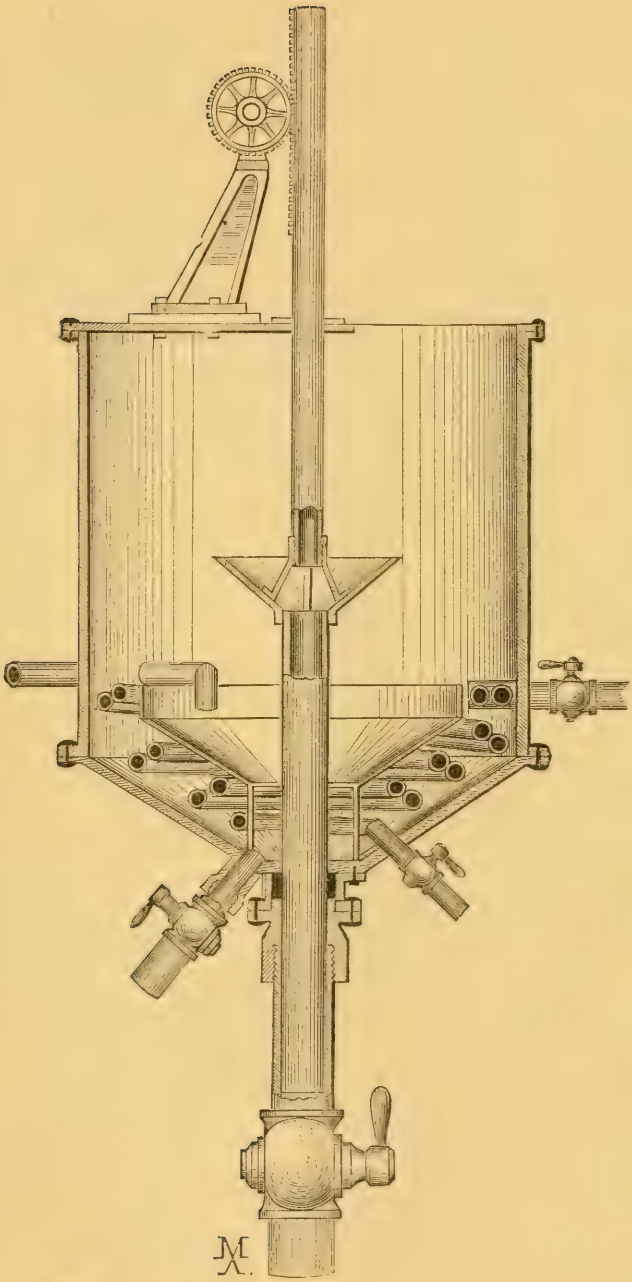
McDOWELL'S STEAM PLANT OR TRAIN.

[Vertical view.]

Plate XIII.

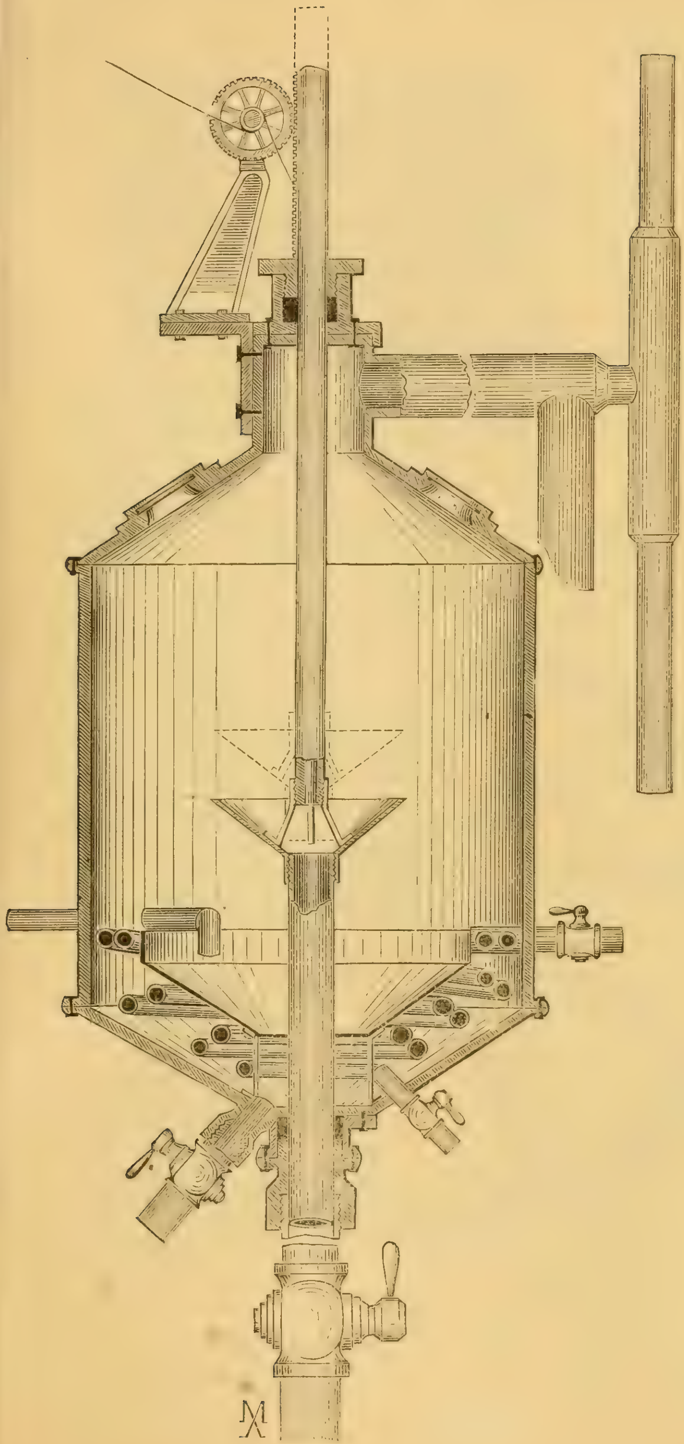


McDOWELL'S DEFECATING TANK.



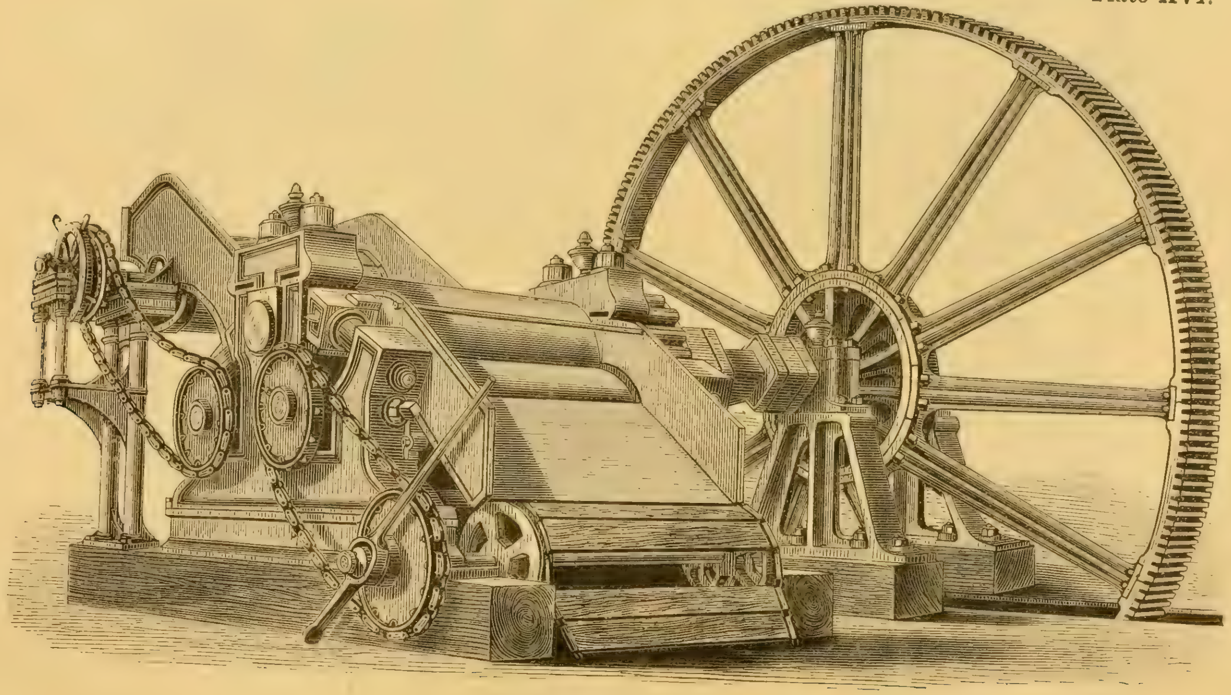
McDOWELL'S EVAPORATOR.

Plate XV.

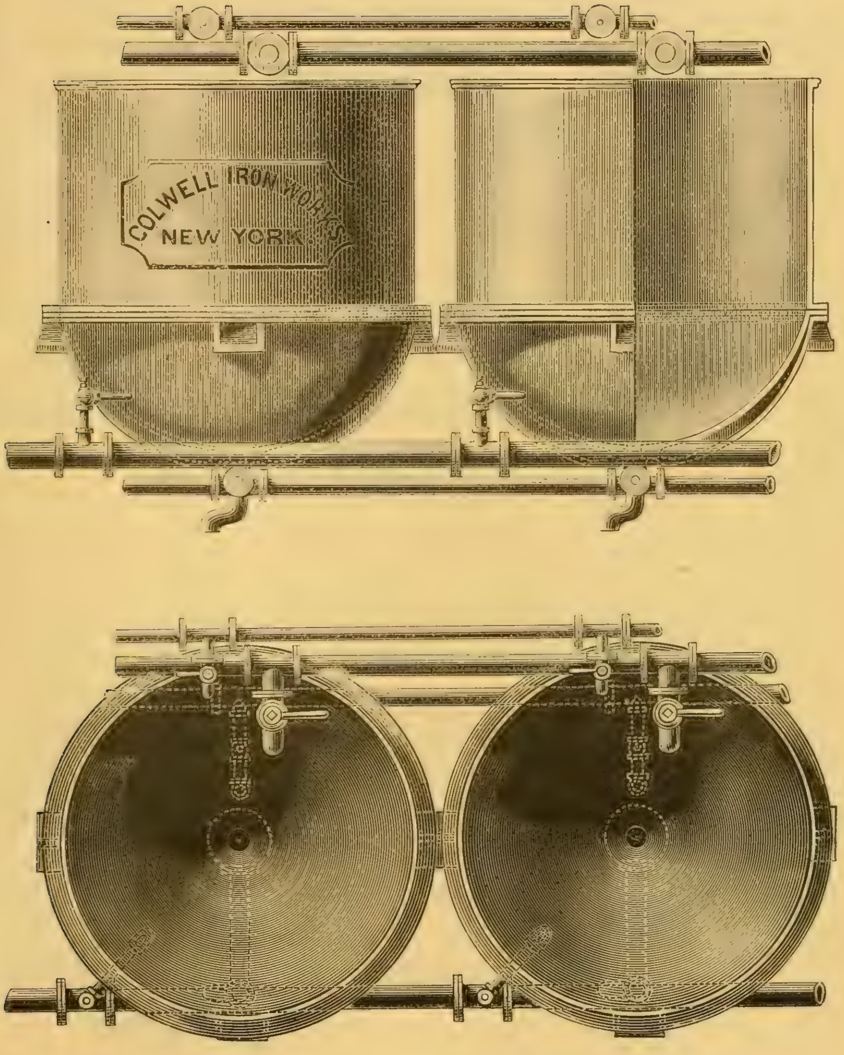


McDOWELL'S CONCENTRATOR.

Plate XVI.

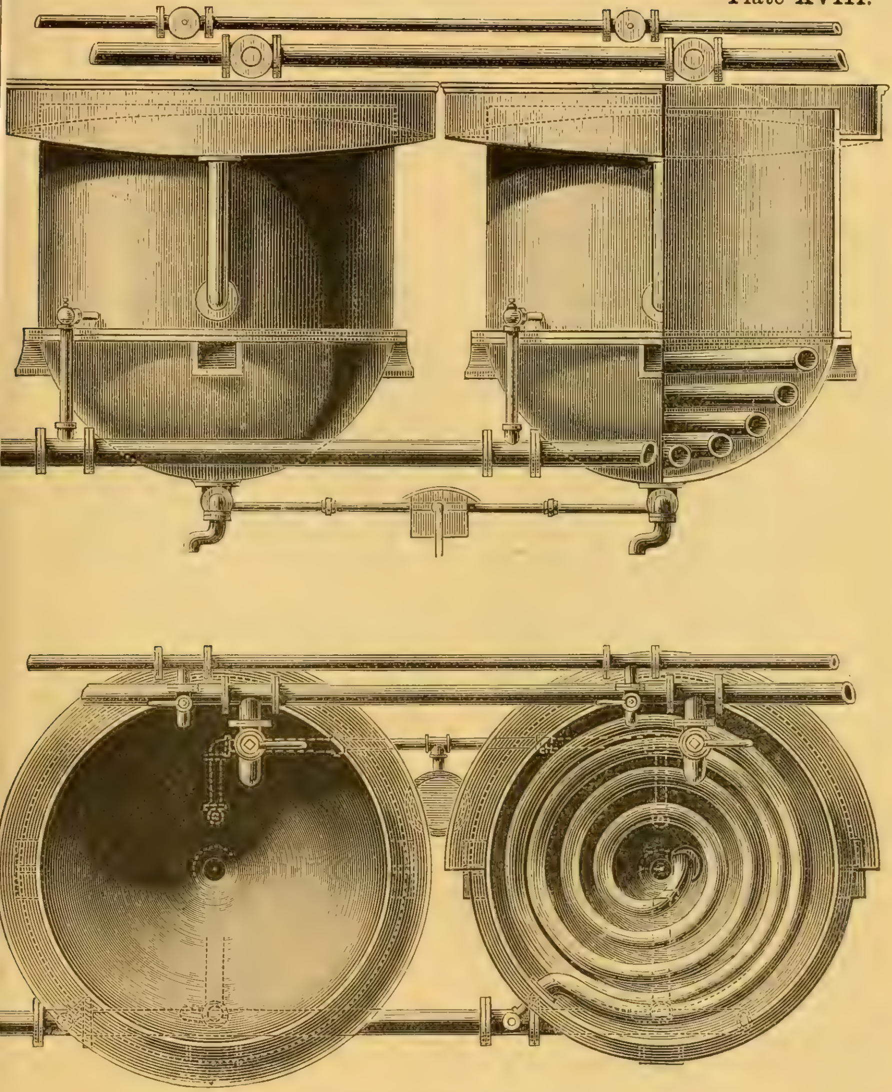


HEAVY CRUSHING MILL.



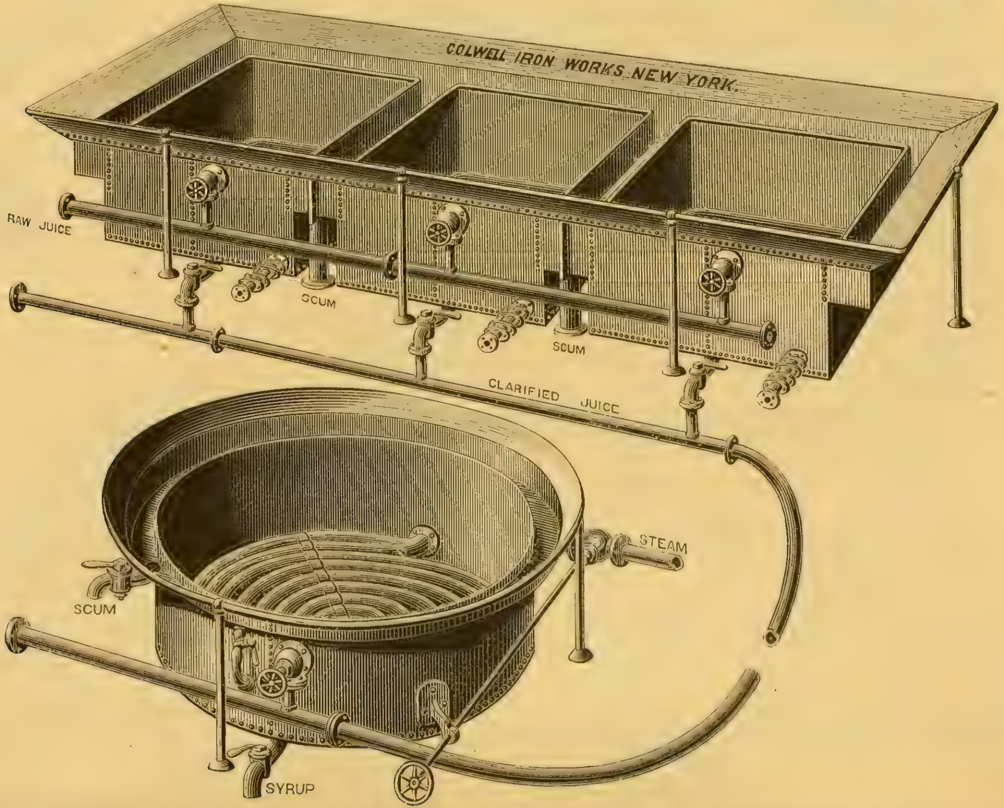
EXHAUST STEAM CLAMPER.

Plate XVIII.

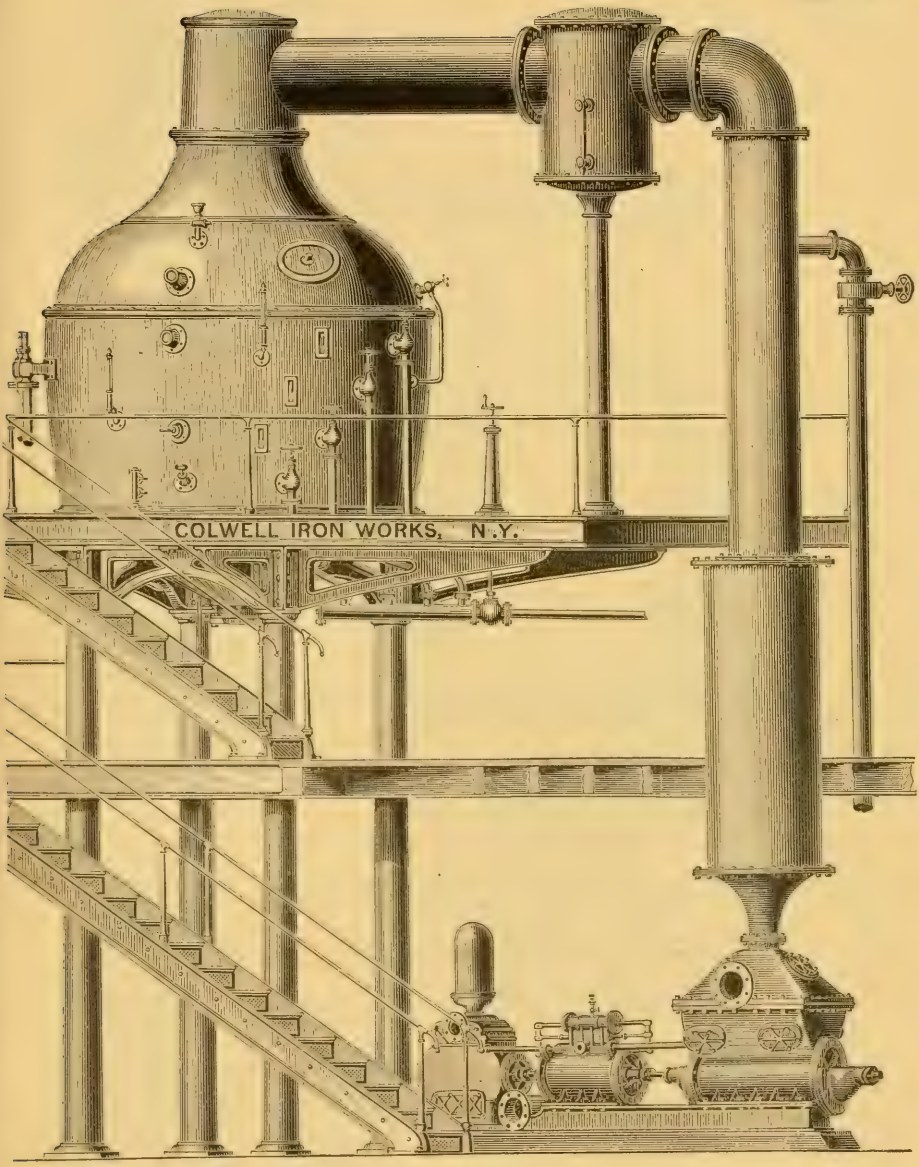


DIRECT STEAM EVAPORATOR.

Plate XIX.

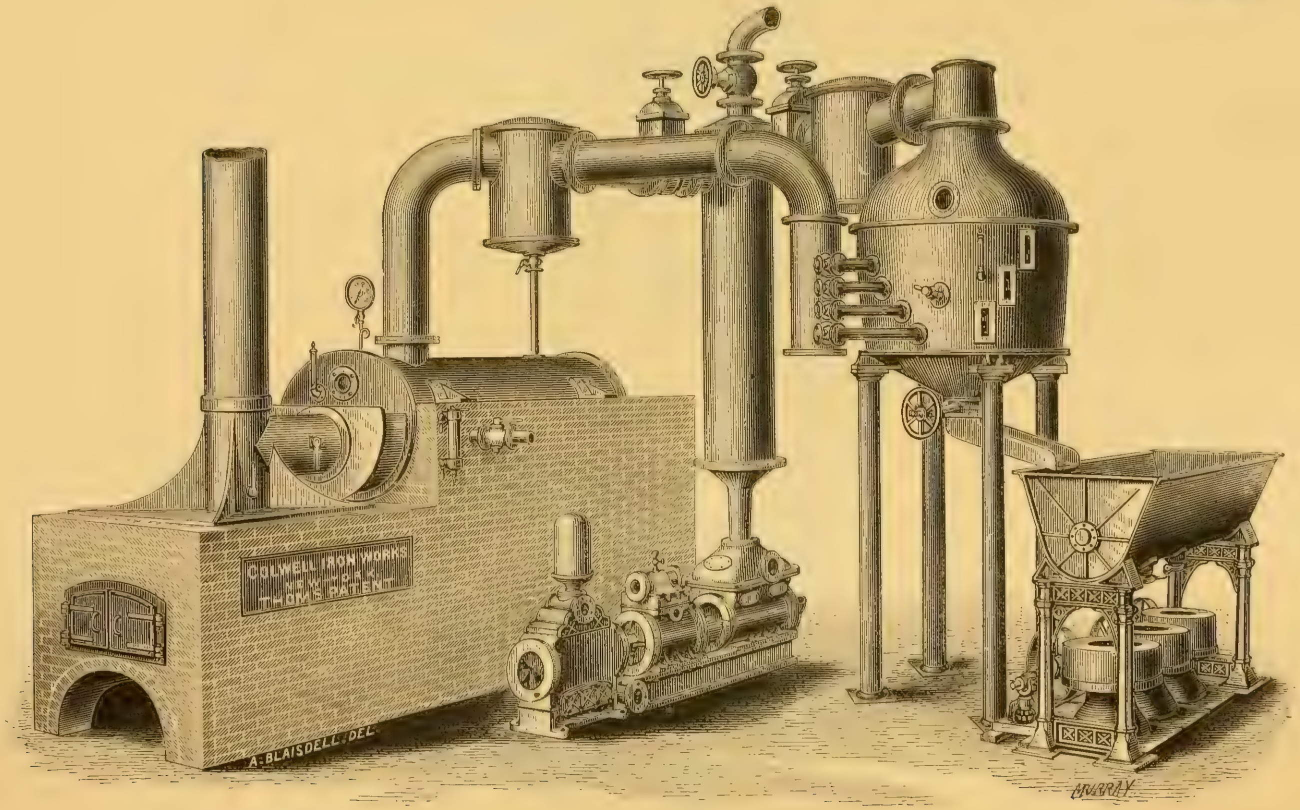


STEAM TRAIN



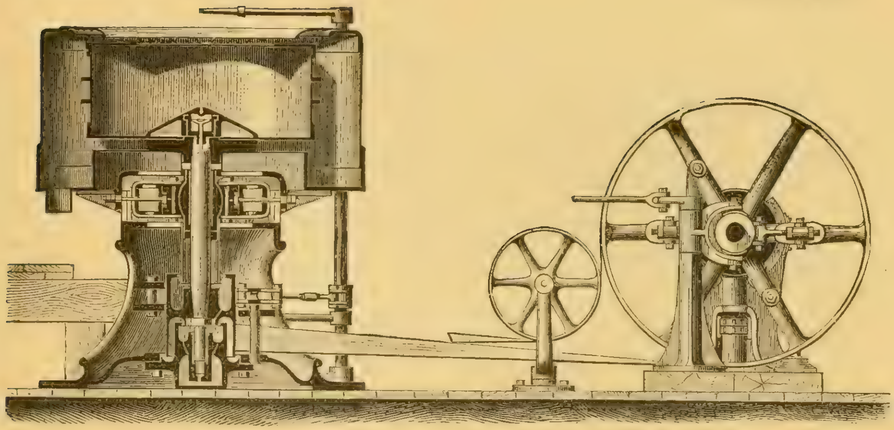
VACUUM PAN.

Plate XXI.



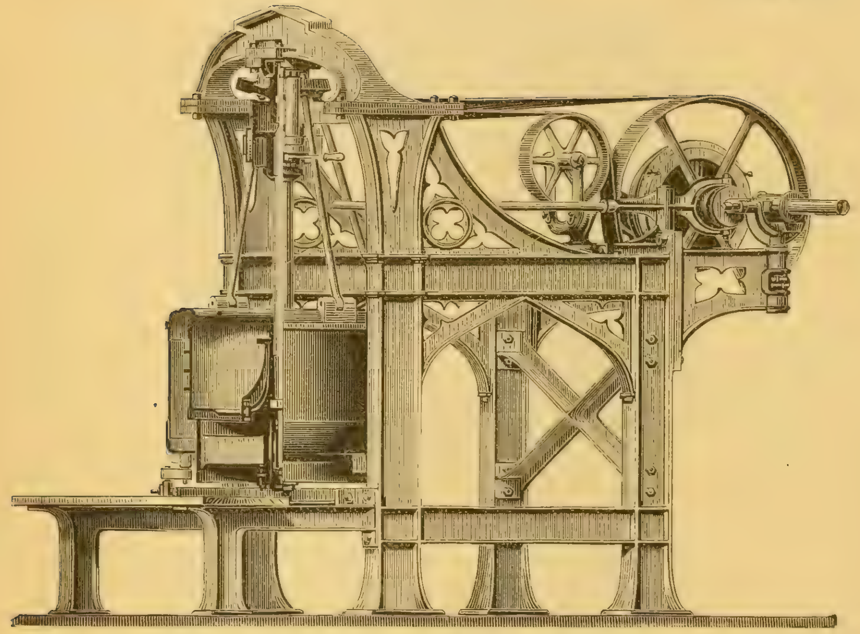
MULTIPLE EFFECT.

Plate XXII.



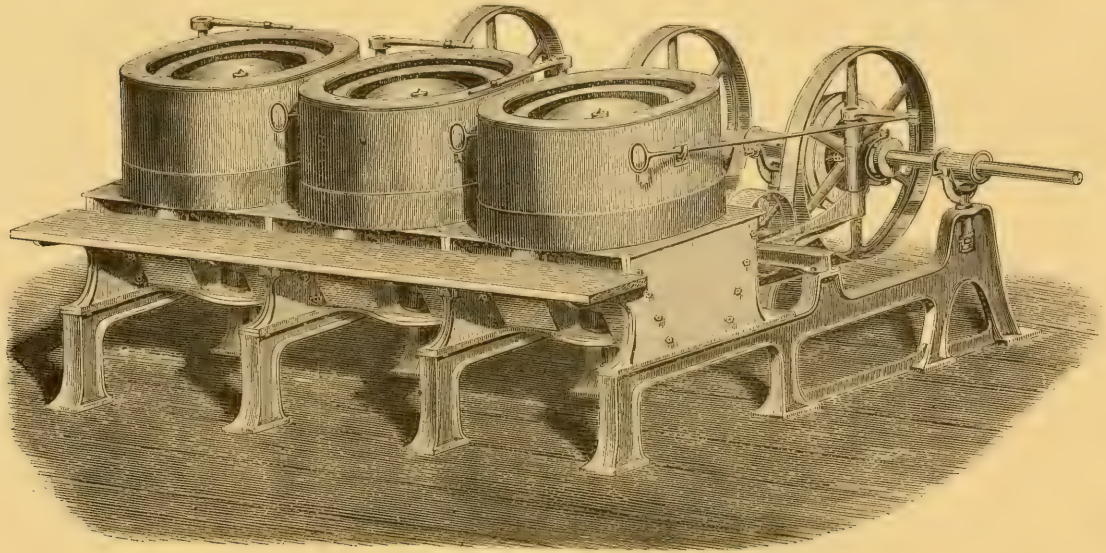
"GERMAN STYLE" CENTRIFUGAL.

Plate XXIII.



HANGING CENTRIFUGAL.

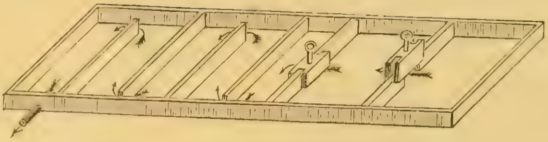
Plate XXIV.



IMPROVED CENTRIFUGAL.

Plate XXV.

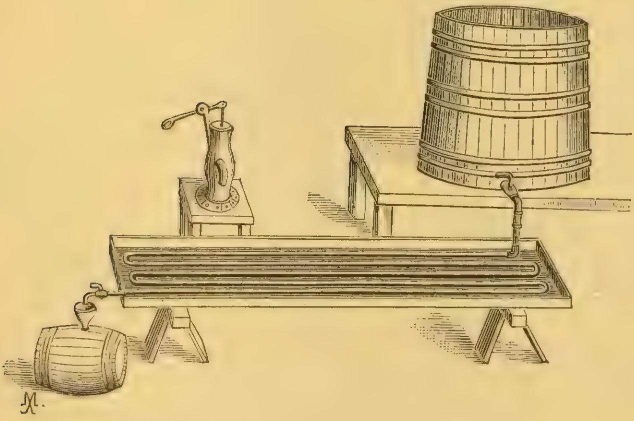
Fig. 1.



COMMON FLAT EVAPORATING PAN.

Wooden sides and partition.

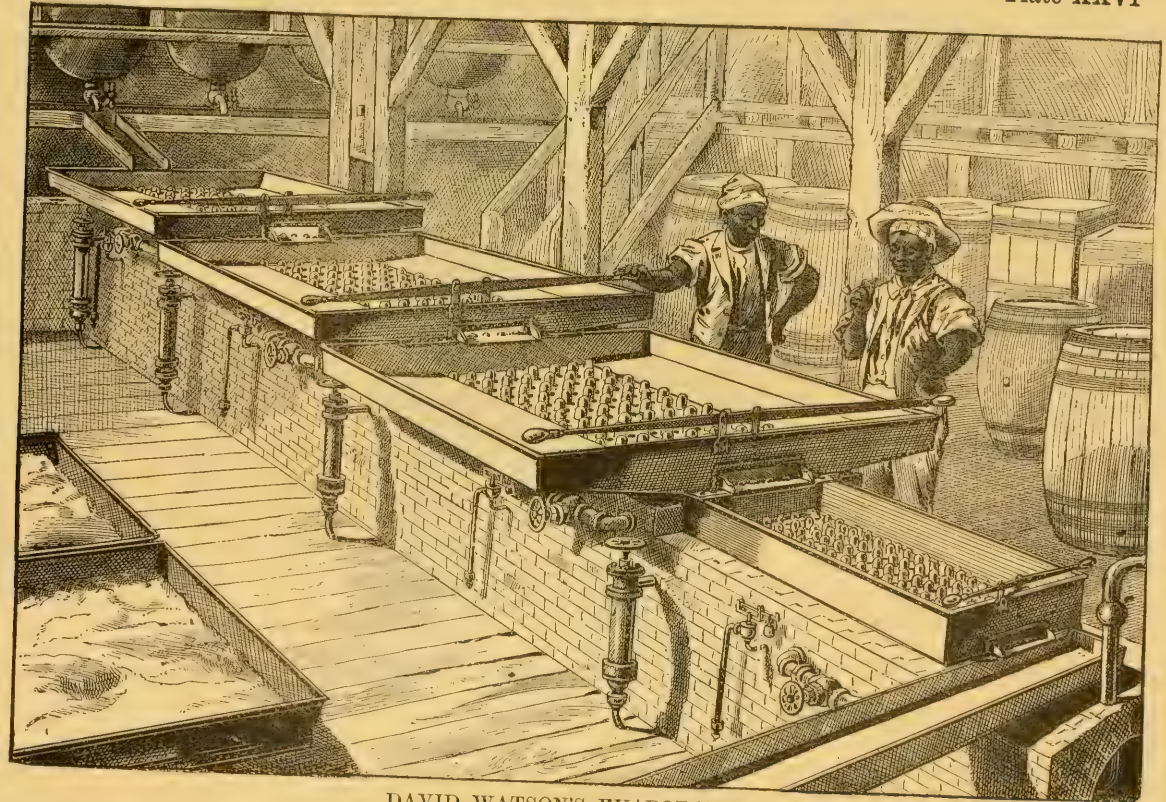
Fig. 2.



COOLING PAN.

The hot sirup passes through the iron pipe immersed in cold water.

Plate XXVI



DAVID WATSON'S EVAPORATOR.

Plate XXVII.

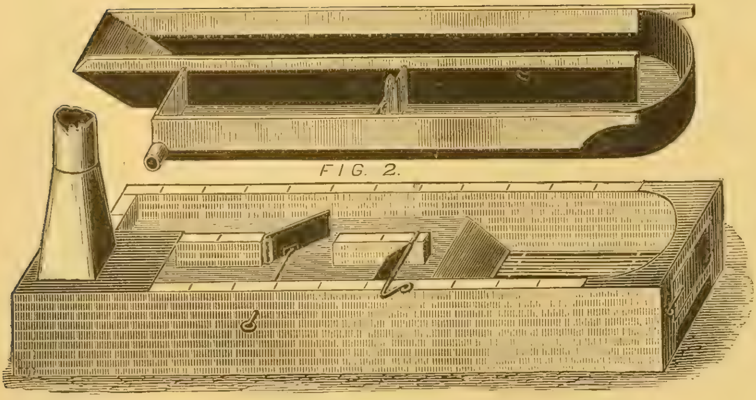


FIG. 2.

STUBB'S EVAPORATOR.

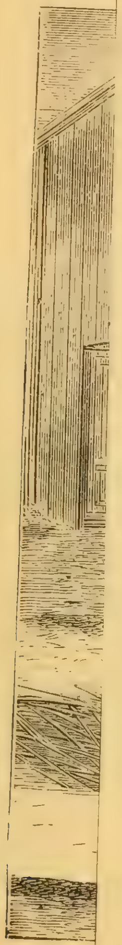
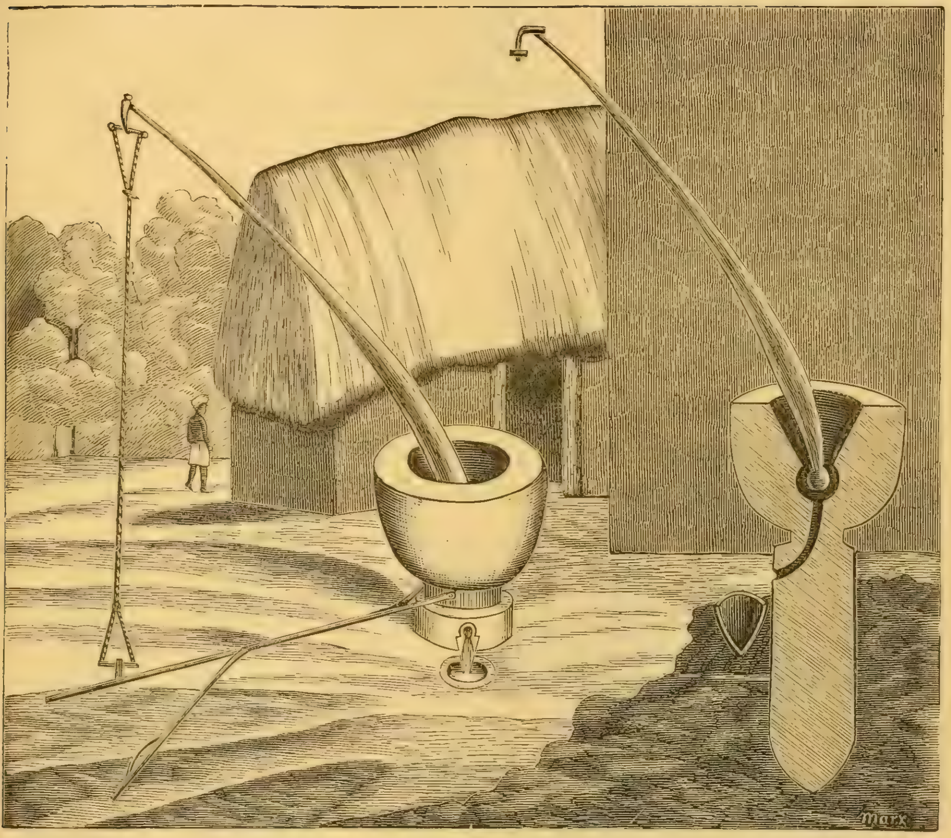


Plate XXVIII.

SUGAR MACHINERY OF THE DEPARTMENT OF AGRICULTURE.

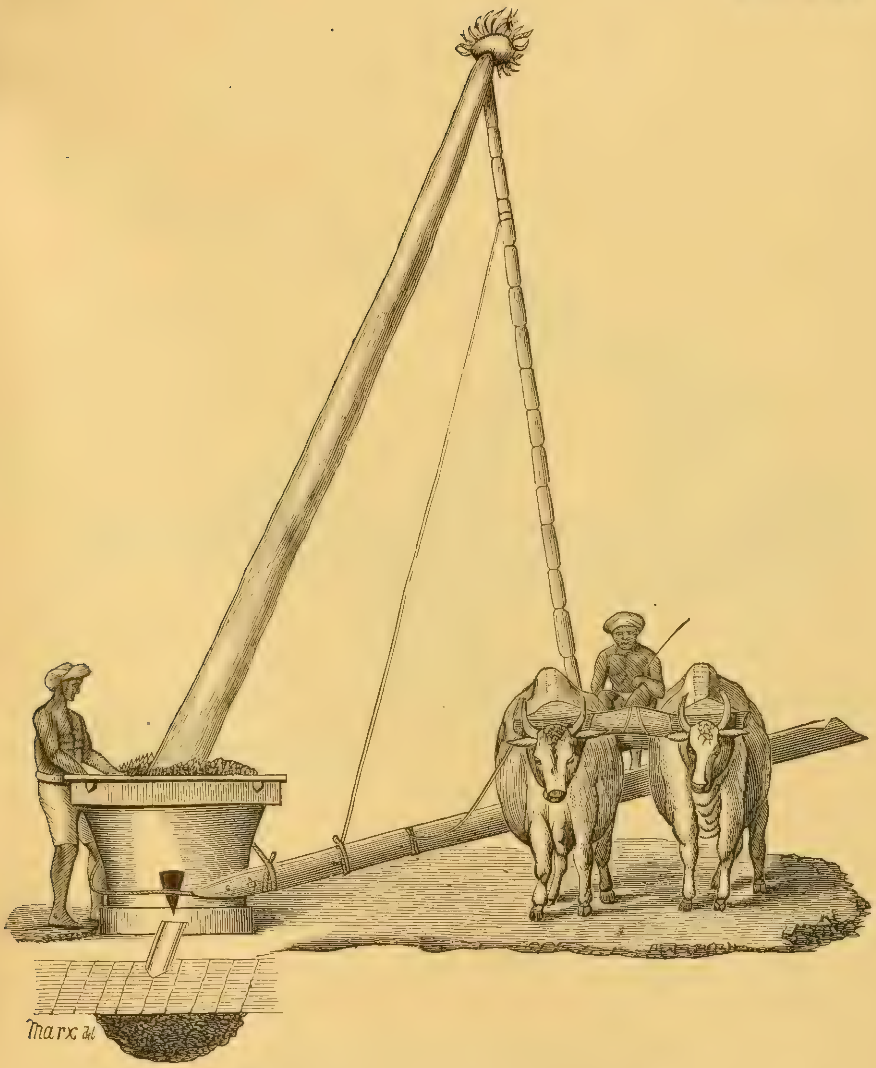
[United States Sugar Mill. Experiments for two years on grounds of Department of Agriculture. Description in the Chemist's Report.]

Plate XXIX.



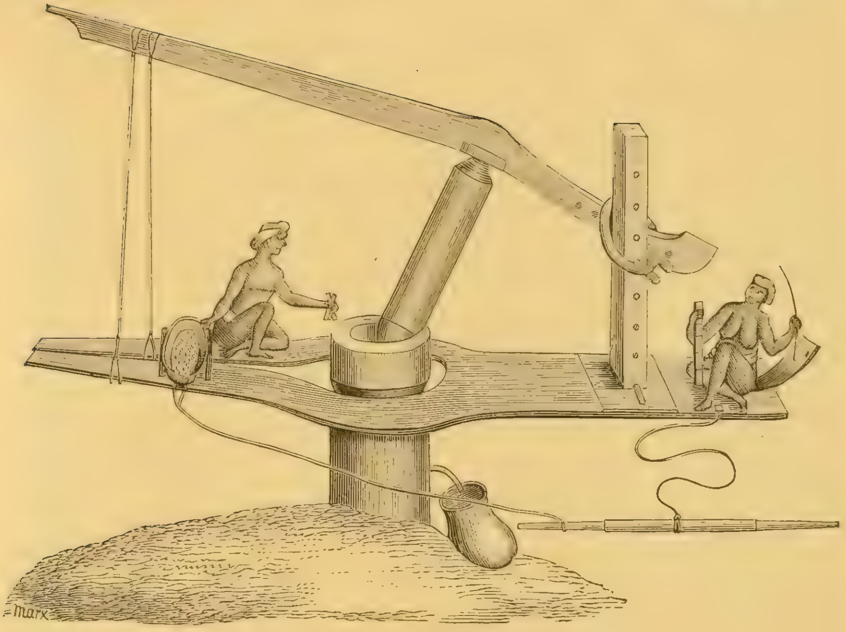
SUGAR MILL IN HINDOOSTAN IN 1800.

Plate XXX.

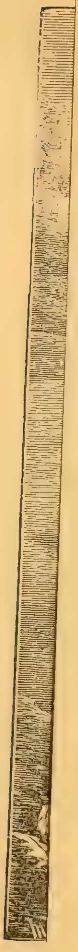


SUGAR MILL IN HINDOOSTAN IN 1800.

Plate XXXI.



SUGAR MILL IN HINDOOSTAN IN 1800.



SUGAR MACHINERY IN HINDOOSTAN IN 1792.

Plate XXXIII.

Fig.2.

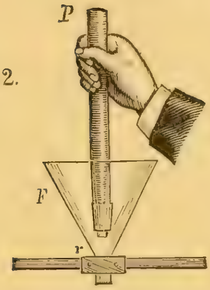
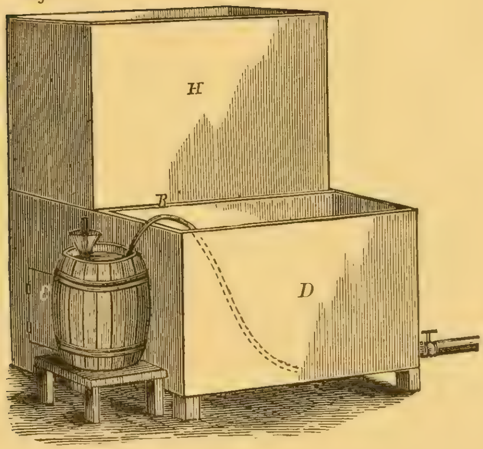


Fig.1.



MACHINERY USED IN STEWART'S PROCESS.